Request by Lamont-Doherty Earth Observatory for an Incidental Harassment Authorization to Allow the Incidental Take of Marine Mammals during a Marine Geophysical Survey by the R/V *Marcus G. Langseth* in the Southeast Pacific Ocean, 2016/2017

submitted by

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to

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TABLE OF CONTENTS

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SUMMARY

Researchers from Oregon State University (OSU) and University of Texas at Austin, Institute for Geophysics (UT), with funding from the U.S. National Science Foundation (NSF), propose to conduct high-energy seismic surveys from the Research Vessel (R/V) *Marcus G. Langseth* (*Langseth*) in the waters off Chile in the southeast Pacific Ocean in 2016/2017. The NSF-owned *Langseth* is operated by Columbia University's Lamont-Doherty Earth Observatory (L-DEO). The proposed seismic surveys would use a towed array of 36 airguns with a total discharge volume of ~6600 in^3. The surveys would take place within the Exclusive Economic Zone (EEZ) and Territorial Waters of Chile in water depths ~50–7600 m. This request is submitted pursuant to Section 101 (a)(5)(D) of the Marine Mammal Protection Act (MMPA), 16 U.S.C. § 1371(a)(5). An IHA covering an effective period of 1 year is requested, as the exact dates of the proposed surveys have not been determined at this time.

Numerous species of marine mammals inhabit the southeast Pacific Ocean. Several of these species are listed as ***Endangered*** under the U.S. Endangered Species Act (ESA): the southern right, humpback, sei, fin, blue, and sperm whales, and the marine otter. Other marine ESA-listed species that could occur in the area include the ***Endangered*** leatherback and loggerhead turtles; the ***Threatened*** green and olive ridley turtles; the ***Threatened*** Humboldt penguin; and the ***Endangered*** scalloped hammerhead shark. The common thresher shark, bigeye thresher shark, porbeagle shark, smooth hammerhead shark, and greytail skate are ***candidate species*** for ESA listing that could occur in the area.

The items required to be addressed pursuant to 50 C.F.R. § 216.104, "Submission of Requests", are set forth below. They include descriptions of the specific operations to be conducted, the marine mammals occurring in the survey areas, proposed measures to mitigate against any potential injurious effects on marine mammals, and a plan to monitor any behavioral effects of the operations on those marine mammals.

I. OPERATIONS TO BE CONDUCTED

A detailed description of the specific activity or class of activities that can be expected to result in incidental taking of marine mammals.

Overview of the Activity

The proposed study consists of three surveys off the coast of Chile in the southeast Pacific Ocean, including: (1) a northern survey to image the region that slipped during the 2014 Pisagua/Iquique earthquake, (2) a central survey to study the area that slipped during the 2015 Illapel earthquake, and (3) a southern survey to examine the deep plate-boundary thrust fault at the south-central Chile margin that has produced some of the world's largest earthquakes and tsunamis (including the largest historic earthquake in 1960, with Mw=9.5, and the 6^{th} largest in 2010, with Mw=8.8). The proposed survey off northern Chile would occur within the area ~70.2–73.2°W, 18.3–22.4°S, the central proposed survey would occur within ~71.8–73.4°W, 30.1–33.9°S, and the southern proposed survey would occur within ~72.2–76.1°W, 33.9–44.1°S (Fig. 1).

Representative survey tracklines are shown in Figure 1; as described further in this document, however, some deviation in actual track lines could be necessary for reasons such as science drivers, poor data quality, inclement weather, or mechanical issues with the research vessel and/or equipment. Water depths in the proposed survey areas range from ~50 to 7600 m. The proposed seismic surveys would be conducted within the EEZ of Chile; only a small proportion of the surveys would take place in Territorial Waters.

The surveys off Chile are proposed for 2016/2017 and would take ~80 days. The proposed survey off northern Chile would consist of ~45 days of science operations that include ~28 days of seismic operations, ~13 days of ocean bottom seismometer (OBS) deployment/retrieval, and ~4 days of transit and towed equipment deployment/retrieval. The central proposed survey would involve ~6 days, including ~5 days of seismic operations and ~1 day of equipment deployment/ retrieval time. The southern proposed survey would involve ~32 days of science operations including ~27 days of seismic operations, and ~5 days of transit and towed equipment deployment/retrieval.

The main goal of the ***northern survey*** proposed by OSU is to image the structure of the upper and lower plates in the region that slipped during the 2014 Pisagua/Iquique earthquake sequence and immediately to the south, where an historic seismic gap remains unruptured, in order to better understand how geologic structure controlled the initiation, propagation, and termination of this rupture sequence. This rupture sequence was marked by an unusually long and distinct precursory period that was well recorded by onshore seismic and geodetic instruments deployed as part of the Integrated Plate Boundary Observatory Chile (IPOC). It only ruptured approximately half of a major recognized seismic gap, and rupture stopped at the edge of a large gravity anomaly, suggesting that a change in crustal structure affected slip propagation. As gravity data are not adequate for resolving the structure, seismic tomography and reflection imaging data would be acquired during this project to develop a high-resolution model of upper and lower plate structure in this region.

The main goal of the ***central survey*** proposed by UT and OSU is to examine the extent and location of seafloor displacement and related subsurface fault movement related to the recent slip during the 16 September 2015 Illapel earthquake. By comparison to existing data acquired prior to this event, these data would provide information on where seafloor displacement occurred, how much displacement there was, and which sub-seafloor faults were mostly likely active during the event. These data are critical for assessing the structures involved in slip, which creates seismic and tsunami hazards that threaten the Chile margin and other locations around the Pacific.

The primary goal of the ***southern survey*** proposed by UT and OSU is to image the deep plate-boundary thrust fault that can produce some of the world's largest earthquakes and tsunamis. The survey is designed to image the characteristics of the plate-boundary thrust, sediment subduction, and upper plate structure within the 2010 Mw 8.8 Maule rupture segment and the 1960 Mw 9.5 Valdivia rupture area. By comparing these structures, it can be determined how the differences in sediment subduction and plate smoothness control the ability of the fault to accumulate strain along the plate interface, and thus control rupture magnitude and earthquake regularity.

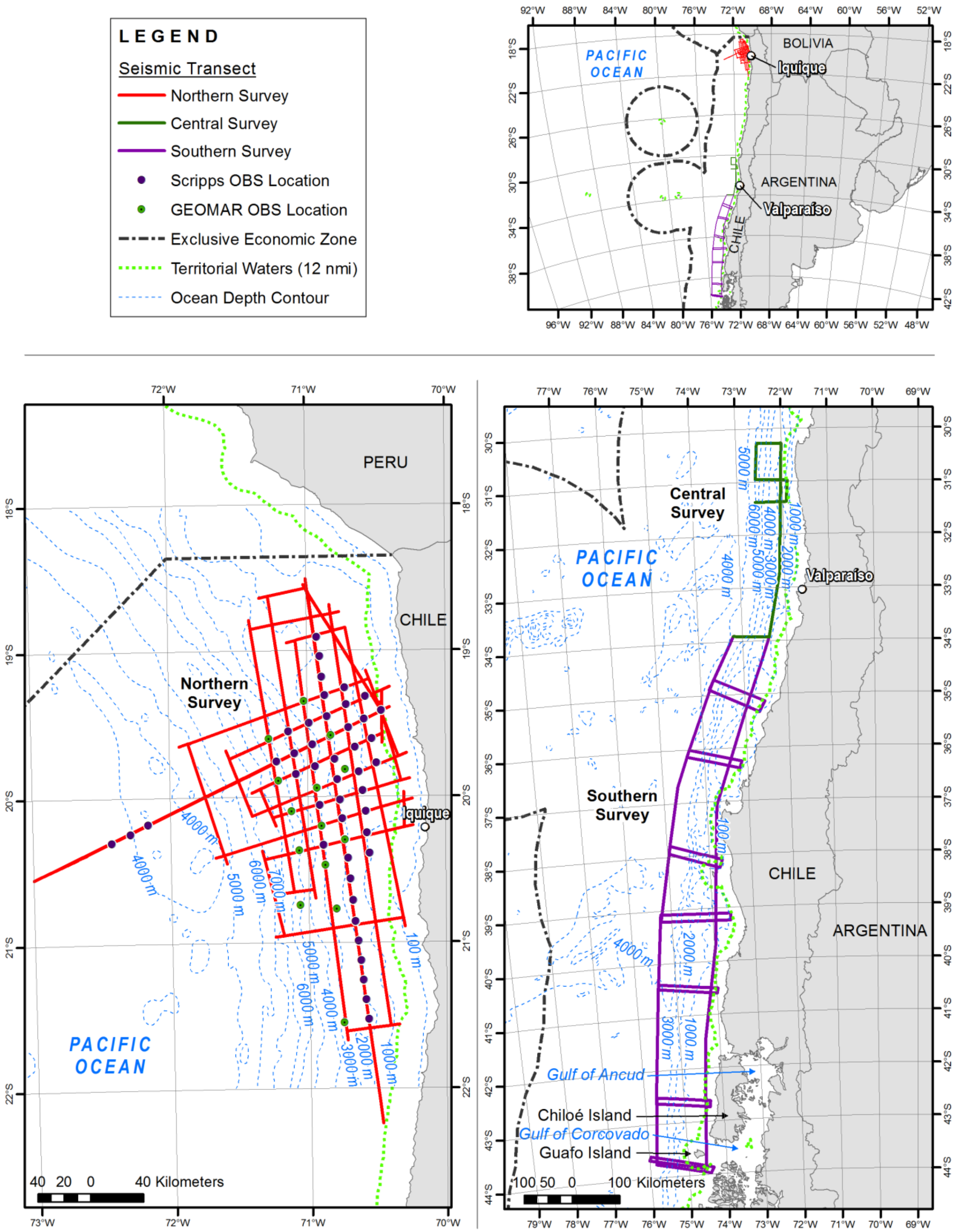


Figure 1. Location of the proposed seismic surveys in the southeast Pacific Ocean during 2016/2017.

To achieve the project goals of the northern survey, the Principal Investigator (PI) Dr. A. Trehu (OSU) proposes to use multi-channel seismic (MCS) surveys and OBS profiles to acquire reflection and refraction profiles to acquire reflection and refraction data, respectively, on the continental margin of northern Chile. Although not funded through NSF, international collaborators Drs. E. Contreras-Reyes, E. Vera, and D. Comte (Universidad de Chile) and H. Kopp and D. Lange (Research Center for Marine Geosciences, GEOMAR, Helmholtz Centre for Ocean Research) would work with Dr. Trehu to achieve the research goals, providing assistance, such as through logistical support and data acquisition, exchange, and interpretation. For the central and southern surveys, Drs. N. Bangs (UT) and A. Trehu propose to use MCS surveys to acquire data on the continental margin of Chile. International collaborators in the proposed southern survey include Drs. E. Contreras-Reyes and E. Vera.

During the northern proposed survey, two two-dimensional (2-D) profiles would be acquired: one, the longest line from southwest to northeast, extending across the source region from the Nazca plate to the coast across the patch of greatest slip during the 2014 earthquake; and the other, the longest north-south line along strike, to image the boundary between the remaining seismic gap and the patch that slipped in 2014. The streamer would be deployed to collect two 2-D profiles with a shot interval of ~25–50 m or ~10–22 s for deep crustal MCS acquisition. The same 2-D profiles would then be acquired with a shot interval of ~300 m or ~2–3 min to the OBSs. Once the long 2-D profiles are completed, the grid of lines (Fig. 1) for three-dimensional (3-D) refraction imaging would be surveyed once for tomography acquisition with a shot interval of ~100–150 m or ~40–60 s. For the central proposed survey, each MCS line of the 2-D survey (Fig. 1) would be acquired once with a shot interval of ~25 m or ~10 s.

The southern proposed survey would consist of a 2-D MCS reflection survey. First, a margin-parallel, deep-penetration profile would be acquired along the margin to examine the along-strike variation in seismic reflectivity of the subduction thrust, and variations in the thickness of sediment subducting into the seismogenic zone. The direction would then be reversed, and a series of 7 margin-perpendicular transects (each having 2 or 3 lines) would be acquired, which would cross the outer rise, trench, and slope, and extend onto the shelf. It would be necessary to go close to the shoreline to image the plate interface as deep into the seismogenic zone as possible. The exact locations of the perpendicular transects may not be as shown in Figure 1, as they would be based on preliminary results from seismic acquisition along the margin-parallel transect along the continental shelf. The margin-perpendicular lines would be connected by another margin-parallel line along the outer rise (Fig. 1). Each MCS line would be shot once at an interval of ~37.5 m or ~16 s.

The procedures to be used for the proposed surveys would be similar to those used during previous seismic surveys by L-DEO and would use conventional seismic methodology. The surveys would involve one source vessel, the *Langseth*, which is owned by NSF and operated on its behalf by Columbia University's L-DEO. The *Langseth* would deploy an array of 36 airguns as an energy source with a total volume of ~6600 in^3. The receiving system would consist of at least 64 OBSs (northern proposed survey) and a single hydrophone streamer 8–15 km in length (all surveys). A longer streamer provides opportunities to suppress unwanted energy that interferes with imaging targets, allows for accurate measurements of seismic velocities, and provides a large amount of data redundancy for enhancing seismic images during data processing. As the airgun array is towed along the survey lines, the OBSs would receive and store the returning acoustic signals internally for later analysis, and the hydrophone streamer would transfer the data to the on-board processing system.

A total of ~9630 km of transect lines would be surveyed in the southeast Pacific Ocean: ~4540 km off northern Chile, ~790 km during the central proposed survey, and ~4300 km during the southern proposed survey (Fig. 1). Approximately 9% of line km (mostly during the southern proposed survey) would occur within Territorial Waters. Effort in water <100 m deep would amount to ~3% of the total line km.

In addition to the operations of the airgun array, a multibeam echosounder (MBES) and a sub-bottom profiler (SBP) would also be operated from the *Langseth* continuously throughout the proposed surveys. A Liquid Robotics SV2 Wave Glider could be deployed during the surveys for a period of several hours to collect data from seafloor sensors. All planned geophysical data acquisition activity would be conducted by L-DEO with on-board assistance by the scientists who have proposed the study. The vessel would be self-contained, and the crew would live aboard the vessel.

Source Vessel Specifications

The R/V *Marcus G. Langseth* is described in § 2.2.2.1 of the Final Programmatic Environmental Impact Statement (PEIS)/Overseas Environmental Impact Statement (OEIS) for Marine Seismic Research funded by the National Science Foundation or Conducted by the U.S. Geological Survey (NSF and USGS 2011) and Record of Decision (NSF 2012), referred to herein as the PEIS. The vessel speed during seismic operations would be 4.5 kt (~8.3 km/h).

Airgun Description

During the survey, the *Langseth* full array consisting of four strings with 36 airguns (plus 4 spares) and a total volume of ~6600 in^3, would be used. The airgun arrays are described in § 2.2.3.1 of the PEIS, and the airgun configurations are illustrated in Figures 2-11 to 2-13 of the PEIS. The 4-string array would be towed at a depth of 9–12 m during the northern proposed survey; the central and southern proposed surveys would use a tow depth of 9 m. The shot intervals would range from 25–50 m for MCS acquisition, 100–150 m for simultaneous MCS and tomography acquisition, and 300 m for tomography acquisition.

Predicted Sound Levels

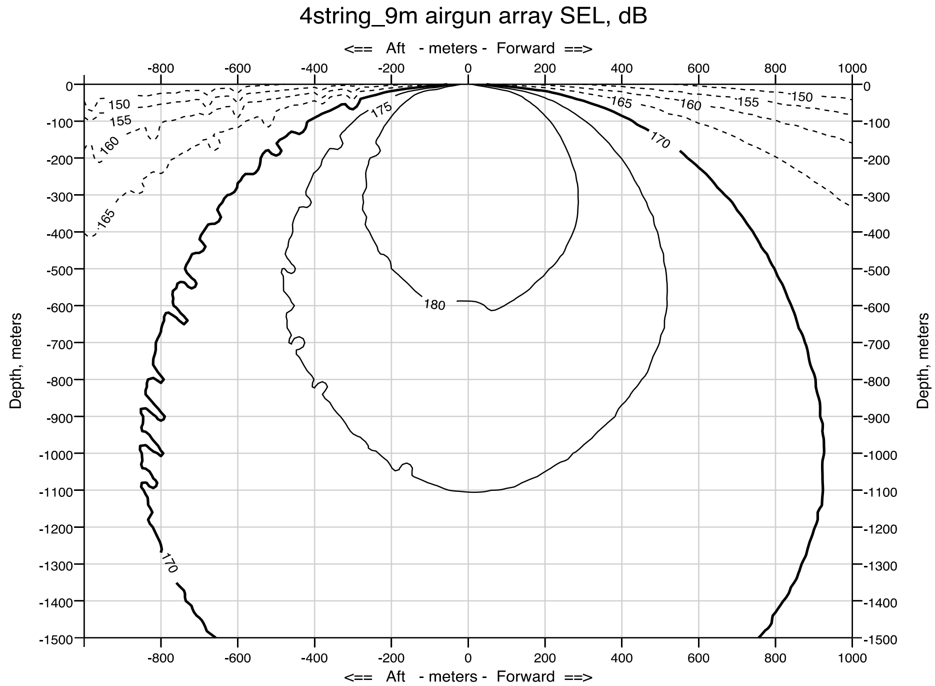
During the planning phase, mitigation zones for the proposed marine seismic surveys were calculated based on modeling by L-DEO for both the exclusion and the safety zones. Received sound levels have been predicted by L-DEO's model (Diebold et al. 2010, provided as Appendix H in the PEIS), as a function of distance from the airguns, for the 36-airgun array at any tow depth and for a single 1900LL 40-in^3 airgun, which would be used during power downs. This modeling approach uses ray tracing for the direct wave traveling from the array to the receiver and its associated source ghost (reflection at the air-water interface in the vicinity of the array), in a constant-velocity half-space (infinite homogeneous ocean layer, unbounded by a seafloor). In addition, propagation measurements of pulses from the 36-airgun array at a tow depth of 6 m have been reported in deep water (~1600 m), intermediate water depth on the slope (~600–1100 m), and shallow water (~50 m) in the Gulf of Mexico (GoM) in 2007–2008 (Tolstoy et al. 2009; Diebold et al. 2010).

For deep and intermediate-water cases, the field measurements cannot be used readily to derive mitigation radii, as at those sites the calibration hydrophone was located at a roughly constant depth of 350–500 m, which may not intersect all the sound pressure level (SPL) isopleths at their widest point from the sea surface down to the maximum relevant water depth for marine mammals of ~2000 m. Figures 2 and 3 in Appendix H of the PEIS show how the values along the maximum SPL line that connects the points where the isopleths attain their maximum width (providing the maximum distance associated with each sound level) may differ from values obtained along a constant depth line. At short ranges, where the direct arrivals dominate and the effects of seafloor interactions are minimal, the data recorded at the deep and slope sites are suitable for comparison with modeled levels at the depth of the calibration hydrophone. At longer ranges, the comparison with the mitigation model—constructed from the maximum SPL through the entire water column at varying distances from the airgun array—is the most relevant. The results are summarized below.

In deep and intermediate water depths, comparisons at short ranges between sound levels for direct arrivals recorded by the calibration hydrophone and model results for the same array tow depth are in good agreement (Fig. 12 and 14 in Appendix H of the PEIS). Consequently, isopleths falling within this domain can be predicted reliably by the L-DEO model, although they may be imperfectly sampled by measurements recorded at a single depth. At greater distances, the calibration data show that seafloor-reflected and sub-seafloor-refracted arrivals dominate, whereas the direct arrivals become weak and/or incoherent (Fig. 11, 12, and 16 in Appendix H of the PEIS). Aside from local topography effects, the region around the critical distance (~5 km in Fig. 11 and 12, and ~4 km in Fig. 16 in Appendix H of the PEIS) is where the observed levels rise closest to the mitigation model curve. However, the observed sound levels are found to fall almost entirely below the mitigation model curve (Fig. 11, 12, and 16 in Appendix H of the PEIS). Thus, analysis of the GoM calibration measurements demonstrates that although simple, the L-DEO model is a robust tool for conservatively estimating mitigation radii. In shallow water (<100 m), the depth of the calibration hydrophone (18 m) used during the GoM calibration survey was appropriate to sample the maximum sound level in the water column, and the field measurements reported in Table 1 of Tolstoy et al. (2009) for the 36-airgun array at a tow depth of 6 m can be used to derive mitigation radii.

The proposed surveys would acquire data with the 36-airgun array at tow depths of 9 and 12 m. For deep water (>1000 m), we use the deep-water radii obtained from L-DEO model results down to a maximum water depth of 2000 m (Fig. 2 and 3). The radii for intermediate water depths (100–1000 m) are derived from the deep-water ones by applying a correction factor (multiplication) of 1.5, such that observed levels at very near offsets fall below the corrected mitigation curve (Fig. 16 in Appendix H of the PEIS). The shallow-water radii are obtained by scaling the empirically derived measurements from the GoM calibration survey to account for the differences in tow depth between the calibration survey (6 m) and the proposed survey (9 and 12 m); whereas the shallow water GOM may not exactly replicate the shallow water environment at the proposed survey sites, it has been shown to serve as a good and very conservative proxy (Crone et al. 2014). A simple scaling factor is calculated from the ratios of the isopleths calculated by the deep-water L-DEO model, which are essentially a measure of the energy radiated by the source array: the 150-decibel (dB) Sound Exposure Level (SEL)[1] corresponds to deep-water maximum radii of 9334 m and 11,250 m for 9 and 12-m tow depths, respectively (Fig. 2 and 3), and 7244 m for a 6-m tow depth (Fig. 4), yielding scaling factors of 1.29 and 1.55 to be applied to the shallow-water 6-m tow depth results. Similarly, the 170 dB SEL corresponds to maximum deep-water radii of 927 and 1117 m for 9 and 12-m tow depths (Fig. 2) and 719 m for 6-m tow depth (Fig. 4), yielding the same 1.29 and 1.55 scaling factors. Measured 160-, 180-, and 190-dB re 1µPa$_{rms}$ distances in shallow water for the 36-airgun array towed at 6 m depth were 17.5 km, 1.6 km, and 458 m, respectively, based on a 95th percentile fit (Tolstoy et al. 2009). Multiplying by 1.29 to account for the tow depth difference between 6 and 9 m yields distances of 22.58 km, 2.06 km, and 591 m, respectively.

[1] SEL (measured in dB re 1 µPa$^2 \cdot$ s) is a measure of the received energy in the pulse and represents the SPL that would be measured if the pulse energy were spread evenly across a 1-s period. Because actual seismic pulses are less than 1 s in duration in most situations, this means that the SEL value for a given pulse is usually lower than the SPL calculated for the actual duration of the pulse. In this EA, we assume that rms pressure levels of received seismic pulses would be 10 dB higher than the SEL values predicted by L-DEO's model.



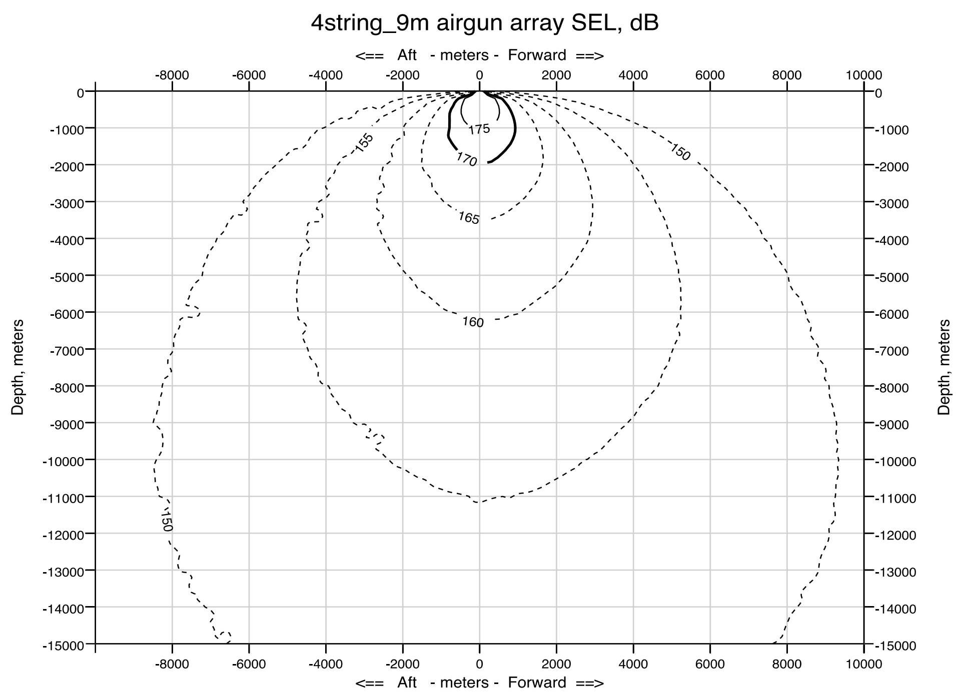


FIGURE 2. Modeled deep-water received sound levels (SELs) from the 36-airgun array planned for use during the proposed surveys in the southeast Pacfic Ocean at a 9-m tow depth. Received rms levels (SPLs) are expected to be ~10 dB higher. The plot at the top provides the radius to the 170-dB SEL isopleth as a proxy for the 180-dB rms isopleth, and the plot at the bottom provides the radius to the 150-dB SEL isopleth as a proxy for the 160-dB rms isopleth.

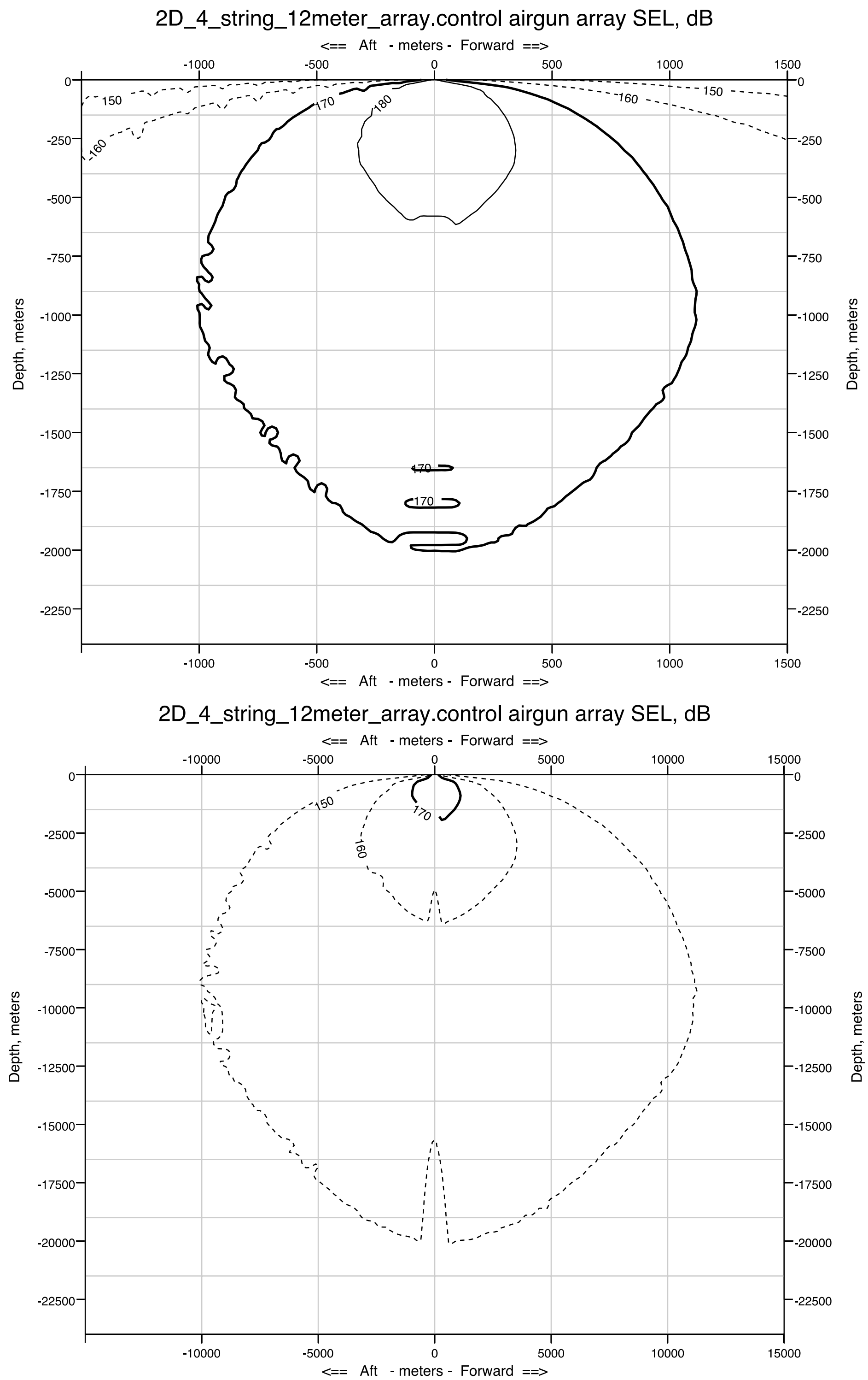
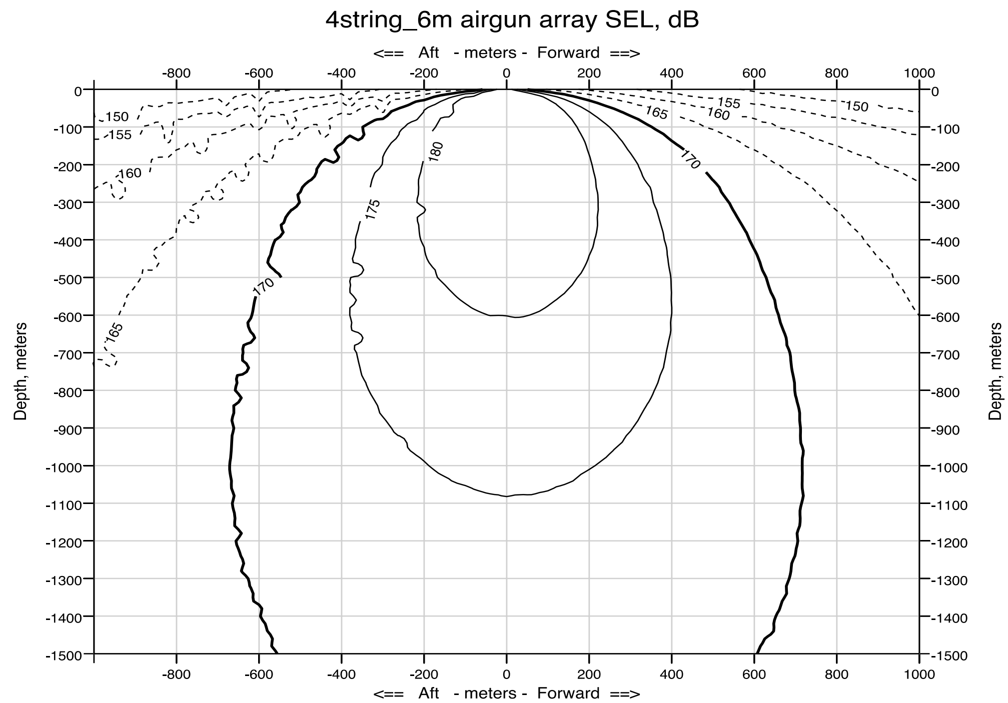


FIGURE 3. Modeled deep-water received sound levels (SELs) from the 36-airgun array planned for use during the proposed surveys in the southeast Pacific Ocean at a 12-m tow depth. Received rms levels (SPLs) are expected to be ~10 dB higher. The plot at the top provides the radius to the 170-dB SEL isopleth as a proxy for the 180-dB rms isopleth, and the plot at the bottom provides the radius to the 150-dB SEL isopleth as a proxy for the 160-dB rms isopleth.



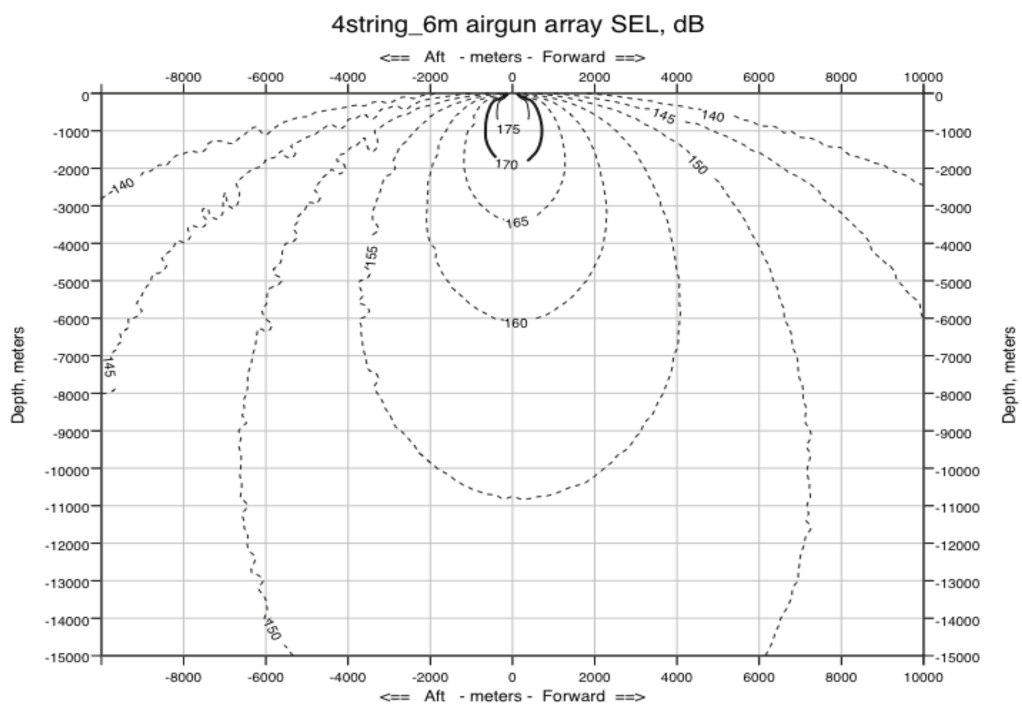


FIGURE 4. Modeled deep-water received sound levels (SELs) from the 36-airgun array at a 6-m tow depth used during the GoM calibration survey. Received rms levels (SPLs) are expected to be ~10 dB higher. The plot at the top provides the radius to the 170 dB SEL isopleth as a proxy for the 180-dB rms isopleth, and the plot at the bottom provides the radius to the 150-dB SEL isopleth as a proxy for the 160-dB rms isopleth.

Multiplying by 1.55 to account for the tow depth difference between 6 and 12 m yields distances of 27.13 km, 2.48 km, and 710 m, respectively.

Measurements have not been reported for the single 40-in^3 airgun. The 40-in^3 airgun fits under the low-energy source category in the PEIS. In § 2.4.2 of the PEIS, Alternative B (the Preferred Alternative) conservatively applies an exclusion zone (EZ) of 100 m for all low-energy acoustic sources in water depths >100 m. This approach is adopted here for the single Bolt 1900LL 40-in^3 airgun that would be used during power downs. L-DEO model results are used to determine the 160-dB$_{rms}$ radius for the 40-in^3 airgun at 12-m tow depth in deep water (Fig. 5). For intermediate-water depths, a correction factor of 1.5 was applied to the deep-water model results. For shallow water, a scaling of the field measurements obtained for the 36-airgun array was used: the 150-dB SEL level corresponds to a deep-water radius of 431 m for the 40-in^3 airgun at 12-m tow depth (Fig. 4) and 7244 for the 36-airgun array at 6-m tow depth (Fig. 2), yielding a scaling factor of 0.0595. Similarly, the 170-dB SEL level corresponds to a deep-water radius of 43 m for the 40-in^3 airgun at 12-m tow depth (Fig. 4) and 719 m for the 36-gun array at 6-m tow depth (Fig. 2), yielding a scaling factor of 0.0598. Measured 160-, 180-, and 190-dB re 1µPa$_{rms}$ distances in shallow water for the 36-airgun array towed at 6-m depth were 17.5 km, 1.6 km, and 458 m, respectively, based on a 95th percentile fit (Tolstoy et al. 2009). Multiplying by 0.0595 and 0.0598 to account for the difference in array sizes and tow depths yields distances of 1041 m, 96 m, and 27 m, respectively.

Table 1 shows the distances at which the 160-, 180-, and 190- dB re 1µPa$_{rms}$ sound levels are expected to be received for the 36-airgun array and the single (mitigation) airgun. The 180- and 190-dB re 1 µPa$_{rms}$ distances are the safety criteria as specified by NMFS (2000) for cetaceans and pinnipeds, respectively. The 180-dB distance would also be used as the EZ for sea turtles, as required by NMFS in most other recent seismic projects per the Incidental Harassment Authorizations (IHAs). The 160-dB level is the behavioral disturbance criterion that is used to estimate anticipated takes for marine mammals.

A recent retrospective analysis of acoustic propagation of *Langseth* sources in a coastal/shelf environment from the Cascadia Margin off Washington suggests that predicted (modeled) radii (using an approach similar to that used here) for *Langseth* sources were 2–3 times larger than measured in shallow water, so in fact, as expected, were very conservative (Crone et al. 2014). Similarly, preliminary analysis by Crone (2015, L-DEO, pers. comm.) of data collected during a survey off New Jersey in 2014 confirmed that *in situ* measurements and estimates of the 160- and 180-dB distances collected by the *Langseth* hydrophone streamer were similarly 2–3 times smaller than the predicted operational mitigation radii. In fact, five separate comparisons conducted of the L-DEO model with *in situ* received levels[2] have confirmed that the L-DEO model generated conservative exclusion zones, resulting in significantly larger EZs than necessary.

Southall et al. (2007) made detailed recommendations for new science-based noise exposure criteria. In July 2015, NOAA published a revised version of its 2013 draft guidance for assessing the effects of anthropogenic sound on marine mammals (NOAA 2015). At the time of preparation of this request, the content of the final guidelines and how they would be implemented are uncertain. As such, this request has been prepared in accordance with the current NOAA acoustic practices, and the

[2] L-DEO surveys off the Yucatán Peninsula in 2004 (Barton et al. 2006; Diebold et al. 2006), in the Gulf of Mexico in 2008 (Tolstoy et al. 2009; Diebold et al. 2010), off Washington and Oregon in 2012 (Crone et al. 2014), and off New Jersey in 2014 and 2015 (Crone 2015, L-DEO, pers. comm.)

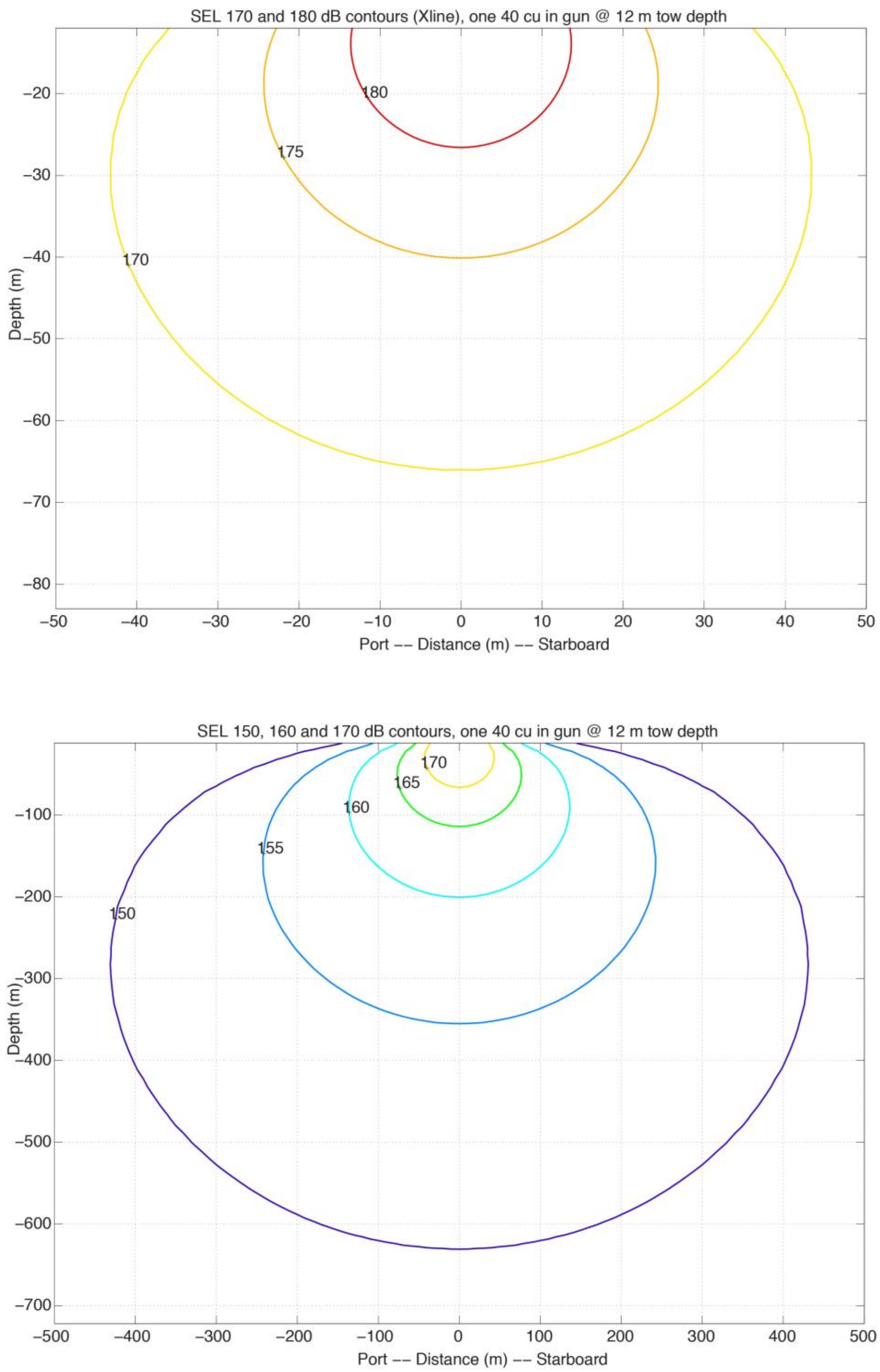


FIGURE 5. Modeled deep-water received sound levels (SELs) from a single 40-in^3 airgun towed at 12 m depth, which is planned for use as a mitigation gun during the proposed surveys in the southeast Pacific Ocean. Received rms levels (SPLs) are expected to be ~10 dB higher. The plot at the top provides the radius to the 170-dB SEL isopleths as a proxy for the 180-dB rms isopleth, and the plot at the bottom provides the radius to the 150-dB SEL isopleth as a proxy for the 160-dB rms isopleth.

TABLE 1. Predicted distances to which sound levels ≥190-, 180-, and 160-dB re 1 μPa$_{rms}$ are expected to be received during the proposed surveys in the southeast Pacific Ocean. For the single mitigation airgun, the EZ is the conservative EZ for all low-energy acoustic sources defined in the PEIS for water depths >100 m and the modeled level for water depths <100 m[5].

Source and Volume	Tow Depth (m)	Water Depth (m)[1]	Predicted rms Radii (m) 190 dB	180 dB	160 dB
Single Bolt airgun, 40 in^3	9 or 12	>1000 m	100	100	431[2]
		100–1000 m	100	100	647[3]
		<100 m	27[4]	96[4]	1041[4]
4 strings, 36 airguns, 6600 in^3	9	>1000 m	286[2]	927[2]	5780[2]
		100–1000 m	429[3]	1391[3]	8670[3]
		<100 m	591[4]	2060[4]	22,580[4]
4 strings, 36 airguns, 6600 in^3	12	>1000 m	348[2]	1116[2]	6908[2]
		100–1000 m	522[3]	1674[3]	10,362[3]
		<100 m	710[4]	2480[4]	27,130[4]

[1] Very few line kilometers (~25 km and 238 km) are planned for water <100 m deep during the northern and southern proposed surveys, respectively.

[2] Distance is based on L-DEO model results.

[3] Distance is based on L-DEO model results with a 1.5 x correction factor between deep and intermediate water depths.

[4] Distance is based on empirically derived measurements in the GoM with scaling applied to account for differences in tow depth.

[3] Modeled distances based on empirically derived measurements in the GoM are smaller.

procedures are based on best practices noted by Pierson et al. (1998), Weir and Dolman (2007), Nowacek et al. (2013), Wright (2014), and Wright and Cosentino (2015).

Enforcement of mitigation zones via power and shut downs would be implemented as described in § XI.

OBS Description and Deployment

During the northern proposed survey, the *Langseth* would deploy ~50 OBSs provided by the Ocean Bottom Seismograph Instrument Pool (OBSIP), which is run by Incorporated Research Institutions for Seismology (IRIS). Nominal OBS spacing would be 15 km. Once all OBSs are deployed, seismic acquisition would commence. Depending on factors such as weather conditions, all OBSs could be recovered at the end of the survey or partial OBS recovery and seismic acquisition could alternate. The OBSs that would be used during the northern proposed survey are from Scripps Institution of Oceanography (SIO). The SIO L-Cheapo OBSs have a height of ~1 m and a maximum diameter of ~1 m. The anchors are 36-kg iron grates with dimensions 7 × 91 × 91.5 cm.

The OBS sites depicted on Figure 1 are representative of the desired configuration for the proposed survey; final sites, however, would be determined after further review of the swath bathymetric data acquired by GEOMAR in this region and geologic conditions assessed during the actual survey as some sites may be deemed unsuitable to achieve the research goals. Most sites are located in water depths <5500 m, where OBSs would be coupled to an anchor on the seafloor. However, some OBS sites could be in water >6000 m deep, where the OBS would be tethered to an anchor on the seafloor and float within the water column at a depth of ~5500 m.

Fourteen additional OBSs funded and deployed by GEOMAR in the region in early December 2015 would be recovered by the *Langseth* during the proposed survey. Another four GEOMAR OBSs could be deployed by the *Langseth* in water >6000 m deep at ~19.8–20.0 °S, 71.3–71.7°W (eliminating the need to tether any SIO OBSs to an anchor), but it is uncertain at the time of writing whether these instruments are available for this project. Once an OBS is ready to be retrieved, an acoustic release transponder interrogates the instrument at a frequency of 8–11 kHz, and a response is received at a frequency of 11.5–13 kHz. The burn-wire release assembly is then activated, and the instrument is released from the anchor to float to the surface. For tethered OBSs, the tether is also recovered.

Description of Operations

The procedures to be used for the proposed marine geophysical surveys would be similar to those used during previous surveys by L-DEO and would use conventional seismic methodology. The surveys would involve one source vessel, the *Langseth*. The *Langseth* would deploy an array of 36 airguns as an energy source with a total volume of ~6600 in^3. The receiving system would consist of at least 64 OBSs (northern proposed survey) and a single hydrophone streamer 8–15 km in length (all surveys). As the airgun array is towed along the survey lines, the OBSs would receive and store the returning acoustic signals internally for later analysis, and the hydrophone streamer would transfer the data to the on-board processing system.

A total of ~9630 km of transect lines would be surveyed in the southeast Pacific Ocean: ~4540 km off northern Chile, ~790 km during the central proposed survey, and ~4300 km during the southern proposed survey (Fig. 1). There could be additional seismic operations associated with turns, airgun testing, and repeat coverage of any areas where initial data quality is sub-standard. In the calculations (see § VII), 25% has been added in the form of operational days, which is equivalent to adding 25% to the proposed line km to be surveyed. In addition to the operations of the airgun array, the ocean floor would be mapped with the Kongsberg EM 122 MBES and a Knudsen Chirp 3260 SBP. These sources are described in § 2.2.3.1 of the PEIS.

A Liquid Robotics SV2 Wave Glider could be used during the surveys for a period of several hours to collect data from seafloor sensors. The Wave Glider is an autonomous marine vehicle that consists of a small sub with sensors that is suspended from a float or platform at the water surface. It is remotely piloted and wave propelled. An integrated acoustic transceiver communicates from the platform to a subsea-mounted acoustic data logger (ADL); the ADL then transfers data to a station on the platform, which transmits them to a control center via satellite. The SV2 Wave Glider platform is 2.1 m long and 60 cm wide. The SV2 Wave Glider would be used and operated in a manner similar to other general types of gliders used for oceanographic research.

II. Dates, Duration, and Region of Activity

The date(s) and duration of such activity and the specific geographical region where it will occur.

The surveys off Chile are proposed for 2016/2017. As the exact dates of the proposed surveys have not been determined at this time, an IHA covering an effective period of 1 year is being requested. The survey off northern Chile would include ~28 days of seismic operations, ~13 days of OBS deployment/retrieval, and ~4 days of transit and towed equipment deployment/retrieval. The central proposed survey would involve ~5 days of seismic operations and ~1 day of equipment deployment/ retrieval time. The southern proposed survey would consist of ~27 days of seismic operations, and ~5 days of transit and towed equipment deployment/retrieval. The *Langseth* would transit to and from the survey locations from either a local port such as Arica, Iquique, or Valparaíso, Chile, or another research survey location in the region.

Seasonality of the proposed survey operations does not affect the ensuing analysis (including take estimates), because the best available species densities for any time of the year have been used. It is likely that fewer baleen whales would be encountered in the region during austral summer, as they are typically found at lower latitudes at that time of the year. An exception is the blue whale, which has been shown to occur in feeding aggregations in the southern portion of the southern proposed survey area during the austral summer, particularly February–April; this has been taken into account in the take estimates.

III. Species and Numbers of Marine Mammals in Area

The species and numbers of marine mammals likely to be found within the activity area

Twenty-nine species of cetaceans (8 mysticetes and 21 odontocetes) and 3 pinniped species could potentially occur in the northern proposed survey area off Chile in the southeast Pacific Ocean. In addition to these, another 10 cetacean species (1 mysticete and 9 odontocetes) and one pinniped species could potentially occur in the central and southern proposed survey areas. The marine otter could also occur in coastal waters adjacent to the proposed survey areas. To avoid redundancy, we have included the required information about the species and (insofar as it is known) numbers of these species in § IV, below.

IV. Status, Distribution and Seasonal Distribution of Affected Species or Stocks of Marine Mammals

A description of the status, distribution, and seasonal distribution (when applicable) of the affected species or stocks of marine mammals likely to be affected by such activities

Sections III and IV are integrated here to minimize repetition.

Of the 44 marine mammal species that may occur within or near the survey areas in the southeast Pacific Ocean, six are listed under the U.S. ESA as ***Endangered***: the southern right, humpback, fin, sei, blue, and sperm whales, and the marine otter. General information on the taxonomy, ecology, distribution and movements, and acoustic capabilities of marine mammals are given in § 3.6.1, § 3.7.1, and § 3.8.1 of the PEIS. The general distributions of marine mammals in the eastern tropical Pacific (ETP) are discussed in the PEIS in § 3.6.2.5 for mysticetes, § 3.7.2.5 for odontocetes, and § 3.8.2.5 for pinnipeds. The rest of this section deals with species distribution in the proposed survey areas off Chile in the southeast Pacific Ocean.

Information on the occurrence near the proposed survey areas, habitat, population size, and conservation status for each of the 44 marine mammal species is presented in Table 2. Although an additional eight species of marine mammals are known to occur in the southeast Pacific Ocean, they are unlikely to occur within the proposed survey areas and are not discussed further here, because their distributions in this region are generally restricted to

(a) latitudes south of ~40°S: Arnoux's beaked whale (*Berardius arnuxii*), Commerson's dolphin (*Cephalorhynchus commersonii*), and spectacled porpoise (*Phocoena dioptrica*);

(b) latitudes north of ~15°S: ginkgo-toothed beaked whale (*Mesoplodon ginkgodens*), Indopacific beaked whale (*Indopacetus pacificus*), and Fraser's dolphin (*Lagenodelphis hosei*); or

(c) farther offshore and more northerly waters: melon-headed whale (*Peponocephala electra*) and spinner dolphin (*Stenella longirostris*).

The waters off northern Chile form part of the Humboldt Current Large Marine Ecosystem, characterized by strong upwelling of nutrient-rich equatorial waters. The upwelling is mostly aseasonal

TABLE 2. The habitat, occurrence, regional population sizes, and conservation status of marine mammals that could occur in or near the proposed survey areas in the southeast Pacific Ocean.

Species	Occurrence Northern Chile	Occurrence Central / Southern Chile	Habitat	Population Size	ESA[1]	IUCN[2]	CITES[3]
Mysticetes							
Southern right whale	Rare	Rare	Coastal, oceanic	12,000[4]	EN	CR	I
Pygmy right whale	–	Rare	Coastal, oceanic	N.A.	NL	DD	I
Humpback whale	Common	Common	Coastal, shelf, pelagic	42,000[4]	EN[5]	LC	I
Common minke whale	Rare	Uncommon	Coastal, pelagic	515,000[6]	NL	LC	I
Antarctic minke whale	Rare	Uncommon	Coastal, pelagic	515,000[6]	NL	DD	I
Bryde's whale	Common	Common	Coastal, pelagic	10,411[7]	NL	DD	I
Sei whale	Uncommon	Uncommon	Mostly pelagic	10,000[8]	EN	EN	I
Fin whale	Uncommon	Common	Shelf, slope, pelagic	15,000[8]	EN	EN	I
Blue whale	Common	Common	Coastal, shelf, pelagic	2300 true[4]; 1500 pygmy[8]	EN	EN	I
Odontocetes							
Sperm whale	Common	Common	Pelagic, deep seas	4,145[7]	EN	VU	I
Dwarf sperm whale	Rare	Rare	Deep shelf, pelagic	11,200[9]	NL	DD	II
Pygmy sperm whale	Rare	Rare	Deep shelf, pelagic	N.A.	NL	DD	II
Cuvier's beaked whale	Uncommon	Uncommon	Slope, pelagic	20,000[9]	NL	LC	II
Shepherd's beaked whale	–	Rare	Pelagic	N.A.	NL	DD	II
Southern bottlenose whale	–	Uncommon	Pelagic	72,000[10]	NL	LC	I
Hector's beaked whale	–	Rare	Pelagic	25,300[9]	NL	DD	II
Gray's beaked whale	Rare	Rare	Pelagic	25,300[9]	NL	DD	II
Pygmy beaked whale	Rare	Rare	Pelagic	25,300[9]	NL	DD	II
Andrew's beaked whale	–	Rare	Pelagic	25,300[9]	NL	DD	II
Strap-toothed whale	–	Rare	Pelagic	25,300[9]	NL	DD	II
Spade-toothed whale	–	Rare	Pelagic	25,300[9]	NL	DD	II
Blainville's beaked whale	Uncommon	Uncommon	Pelagic	25,300[9]	NL	DD	II
Chilean dolphin	–	Uncommon	Coastal	N.A.	NL	NT	II
Rough-toothed dolphin	Rare	–	Oceanic	107,633[11]	NL	LC	II
Common bottlenose dolphin	Abundant	Common	Coastal, shelf, pelagic	335,834[11]	NL	LC	II
Striped dolphin	Rare	Rare	Shelf edge, pelagic	964,362[11]	NL	LC	II
Short-beaked common dolphin	Abundant	Abundant	Coastal, shelf	1,766,551[12]	NL	LC	II
Long-beaked common dolphin	Uncommon	–	Coastal, shelf	N.A.	NL	DD	II
Dusky dolphin	Abundant	Abundant	Shelf, slope	N.A.	NL	DD	II
Peale's dolphin	–	Uncommon	Coastal	N.A.	NL	DD	II
Hourglass dolphin	–	Rare	Pelagic	144,300[13]	NL	LC	II
Southern right whale dolphin	Uncommon	Common	Mostly pelagic	N.A.	NL	DD	II
Risso's dolphin	Common	Uncommon	Mostly shelf, slope	110,457[11]	NL	LC	II
Pygmy killer whale	Rare	Uncommon	Deep, pantropical	38,900[9]	NL	DD	II
False killer whale	Uncommon	Rare	Pelagic	39,800[9]	NL	DD	II
Killer whale	Rare	Rare	Coastal, shelf, pelagic	8,500[14]	NL	DD	II
Long-finned pilot whale	Common	Common	Coastal, pelagic	200,000[8]	NL	DD	II
Short-finned pilot whale	Uncommon	Uncommon	Coastal, pelagic	589,315[7]	NL	DD	II
Burmeister's porpoise	Uncommon	Uncommon	Coastal	N.A.	NL	DD	II
Pinnipeds							
Juan Fernández fur seal	Rare	Rare	Coastal, pelagic	32,278[15]	NL	LC	II
South American fur seal	Common	– / Rare[16]	Coastal, shelf, slope	24,589[17]	NL	LC	II
South American sea lion	Abundant	Abundant	Coastal, shelf	255,036[18]	NL	LC	NL
Southern elephant seal	Extralimital	Rare	Coastal, pelagic	640,000[19]	NL	LC	II
Lutrinids							
Marine otter	Rare	Rare	Coastal	789-2131[20]	EN	EN	I

N.A. = Not available. '–' = Absent from proposed survey area(s).

[1] U.S. Endangered Species Act (NMFS 2015a; USFWS 2015): EN = Endangered; NL = Not Listed.
[2] Classification from the International Union for the Conservation of Nature (IUCN) Red List of Threatened Species (IUCN 2015): CR = Critically Endangered; EN = Endangered; VU = Vulnerable; NT = Near Threatened; LC = Least Concern; DD = Data Deficient.
[3] Convention on International Trade in Endangered Species of Wild Fauna and Flora (UNEP-WCMC 2015): Appendix I = Threatened with extinction; Appendix II = not necessarily now threatened with extinction but may become so unless trade is closely controlled.
[4] IWC (2015).
[5] NMFS has recently (April 2015) proposed that 14 distinct population segments (DPSs) of humpback whales should be recognized and that 10 of those should be delisted, including the Southeastern Pacific DPS (NMFS 2015b).
[6] Best estimate for the Southern Hemisphere from 1992/1993 to 2003/2004 sighting data; common and Antarctic minke whales combined (IWC 2015).
[7] ETP (Gerrodette and Forcada 2002).
[8] Antarctic (Boyd 2002).
[9] ETP; for *Mesoplodon* spp., only one density was reported (Wade and Gerrodette 1993).
[10] South of 60°S from the 1885/1986–1990/1991 IWC/IDCR and SOWER surveys (Branch and Butterworth 2001).
[11] ETP, line-transect survey, August-December 2006 (Gerrodette et al. 2008).
[12] ETP, southern stock, 2000 survey (Gerrodette and Forcada 2002).
[13] South of the Antarctic Convergence in January (Kasamatsu and Joyce 1995).
[14] ETP (Forney and Wade 2006).
[15] 2005/2006 minimum population estimate (Osman 2008).
[16] Absent and rare in the proposed central and southern survey areas, respectively.
[17] Population in Chile (Venegas et al. 2002).
[18] Pacific population, Chile and Peru (Dans et al. 2012).
[19] Southern Ocean population (Hindell and Perrin 2009).
[20] Peruvian coast (Valqui 2012a).

in northern Chile and species composition in this region may be more dependent on interannual variability, such as that caused by El Niño events, rather than intra-annual (seasonal) variability (Aguayo-Lobo et al. 1998; Thiel et al. 2007). Thus, both tropical and temperate species could occur off northern Chile, depending on the environmental conditions at the time of the survey. In contrast, upwelling in the central/southern region of Chile is more seasonal in nature, and the area is characterized by cold Humboldt Current water (Aguayo-Lobo et al. 1998; Thiel et al. 2007). Thus, cold water high-latitude species are more likely to occur in this region.

Little is known about the distributions of most cetacean species in the proposed survey areas off Chile, but the available information is provided in the species descriptions below. Most information is taken from Aguayo-Lobo et al. (1998), who provided a detailed summary on the occurrence of cetaceans in all Chilean waters compiled from several sources and separated into northern, central, and southern Chile. The northern region extended as far south as 32.2°S, inclusive of the northern and most of the central proposed survey areas. The central region extended from 32.2 to 39.9°S, including the remainder of the central and the northern half of the southern proposed survey areas. The southern region extended from 40°S to the Antarctic Convergence at 60°S, including the southern half of the southern proposed survey area. The main data sources used were two reports prepared previously by those authors (Torres et al. 1990, Aguayo and Torres 1993 *in* Aguayo- Lobo et al. 1998) for submission to the General Secretariat of the Comisión Permanente del Pacífico Sur (CPPS). The authors revised and updated the information in those reports to provide a comprehensive assessment, adding information from French and American whaling records (Du Pasquier 1986 and Townsend 1935, respectively, *in* Aguayo-Lobo et al. 1998) as well as from scientific reports, technical papers, conference proceedings, unpublished data, and written personal communications that they had gathered over the previous 10 years and are held at the Chilean Antarctic Institute (INACH). They provided the number of occurrences and individuals of each species for northern, central, and southern Chile compiled from the sighting, stranding, and catch data.

Aguayo-Lobo et al. (1998) also reported relative abundance estimates (animals per day) for cetaceans available in the published and unpublished literature. For the northern region of Chile, most of these estimates came from a single sighting survey in the summer (December–January) of 1997–1998 conducted as part of the International Whaling Commission (IWC) Southern Ocean Whale and Ecosystem Research (SOWER) Program between 20.2°S and 32.2°S. Estimates were provided for December and January combined (Findlay et al. 1998 *in* Aguayo-Lobo et al. 1998) and for December alone (Hucke-Gaete 1998 *in* Aguayo-Lobo et al. 1998) from that survey.

Abundance estimates are also available from sighting surveys based out of Valparaíso, Chile (33.1°S), which encompassed an area extending as far west as Easter Island, as far south as the Juan Fernández Islands (33.8°S), and as far north as San Félix Island (26.3°S), which is ~900 km southwest of the northern proposed survey area (Aguayo et al. 1998). The surveys spanned the latitudinal boundaries of the central proposed survey area and overlapped with the southern portion of it near Valparaíso. The sighting surveys were conducted during fall and winter (May–September) 1993–1995 and used a relative abundance metric based on the number of animals sighted per day, with day defined as 7.9 h of survey effort with good sighting conditions. Capella et al. (1999) reported cetacean sightings during 1988–1995 around Chañaral Island (29°S) at the Humboldt Penguin National Reserve, ~800 km south of the northern proposed survey area and ~100 km north of the central proposed survey area; the vast majority of sighting effort in that study occurred from late spring through fall (November–April).

Cetacean occurrence information was also retrieved from two online data repositories: (1) the SIBIMAP-PSE (Sistema de Información para Biodiversidad Marina y áreas Protegidas del Pacífico Sudeste) database (available at http://cpps.dyndns.info/sibimap/cetaceos.html), which is a data repository developed by CPPS to facilitate dissemination of information among scientists and policy makers engaged in marine biodiversity conservation in southeast Pacific countries: Chile, Colombia, Ecuador, Panama, and Peru; and (2) the Ocean Biogeographic Information System (OBIS; http://iobis.org). The paucity of sightings from those databases in the proposed survey areas for most species is likely more a reflection of lack of effort rather than the actual distribution of those species in the area. In addition, sightings during a low-energy seismic survey conducted by SIO in May 2012 in the northern portion (~34–35°S, 72.4–74°W) of the proposed southern survey area have also been included in the species descriptions below (SIO 2012). PSOs onboard the seismic source vessel, the R/V *Melville*, watched for marine mammals for at least 149 h during 1105 km of seismic operations.

Mysticetes

Southern Right Whale (*Eubalaena australis*)

The southern right whale occurs throughout the Southern Hemisphere between ~20°S and 60°S (Kenney 2009). It migrates between summer foraging areas at high latitudes and winter breeding and calving areas at low latitudes (Kenney 2009). Its calving and breeding areas generally are located in nearshore waters, whereas the feeding grounds in the Southern Ocean apparently are located mostly in offshore pelagic waters (Kenney 2009). The largest breeding areas are found in Argentina, South Africa, and Australia (Kenney 2009), but there are also calving areas in Brazil, Auckland/Campbell Islands, Chile, and Peru (IWC 2001). The southern right whale is found primarily in water <100 m deep, but a few records have been reported farther offshore (Félix and Escobar 2011).

Southern right whales were exploited off the southern and central coasts of Chile during the whaling era; thus, the current population in that region is much reduced (Aguayo and Torres 1986; Aguayo-Lobo et al. 2008). The Chile-Peru subpopulation of the southern right whale (as recognized by the IUCN) occurs from southern Peru (Santillán et al. 2004; Van Waerebeek et al. 2009) to central Chile (Aguayo and Torres 1986; Aguayo-Lobo et al. 2008) during austral winter and spring, and off southern-most Chile during fall and summer (NMSF 2007; Félix and Escobar 2011). This population does not appear to be increasing (IWC 2007a; Aguayo-Lobo et al. 2008) and is estimated to number as few as 50 mature individuals (Galletti Vernazzani et al. 2011).

Aguayo-Lobo et al. (2008) reviewed all available records of southern right whales along the entire coast of Chile for the 1976–2008 post-whaling era; they reported 115 sightings of 218 individuals, including 37 calves. Concentrations of sightings occurred between 31°S and 41°S (48%) and between 18°S and 25°S (24%). The former overlaps with the southern portion of the central and most of the southern proposed survey areas; the latter encompasses the northern proposed survey area. Galletti Vernazzani et al. (2011) only considered 79 confirmed sightings of 134 whales (including 27 calves) between 1975 and 2010 for their analysis. They found aggregations in northern Chile between 22°S and 26°S, and in central and southern Chile between 30°S and 37°S; sightings north of 20°S were scarce.

Based on data compiled by Aguayo-Lobo et al. (2008), southern right whales were seen within the proposed survey areas from June through March; most sightings in Chile were made from August to October (Aguayo-Lobo et al. 2008; Galletti Vernazzani et al. 2011). From 1964 to 2008, most calves in Chilean waters were reported between 23°S and 25°S and between 32°S and 36°S (Aguayo-Lobo et al. 2008). Calves were reported from late June until early November; except for one calf sighted near 18.5°S in August, all other calves were seen south of 23.3°S (Aguayo-Lobo et al. 2008). Calves were seen off central Chile between the end of July and the end of October. Félix and Escobar (2011) reported that mother-calf pairs were recorded in Chile from June through December during 1964–2011, with a peak during September and October. Cow-calf pairs have been sighted as far north as 12.4°S in Peru (Santillán et al. 2004; Van Waerebeek et al. 2009).

CPPS (2014) used the data compiled in the SIBIMAP database to assess the distribution and habitat use of five large whales occurring in the southeast Pacific Ocean, including the southern right whale. There were 170 sightings of this species in the database during 1963–2010, with a continuous distribution along the coast of Chile to central Peru, mainly in winter and spring (June–November). They were unable to identify areas of concentration or migratory routes, but reported that most sightings occurred between June and October and between 20°S and 40°S. Mothers with calves were seen north of 40°S, primarily in September and October. There are no records of this species in the OBIS database for the proposed northern proposed survey area, but there are 22 and 59 historical whaling records for the central and southern proposed survey areas, respectively (Townsend 1935 *in* OBIS 2015).

Pygmy right whale (*Caperea marginata*)

The distribution of the pygmy right whale is thought to be circumpolar in the Southern Hemisphere between 30°S and 55°S where water temperatures are between ~5°C and 20°C (Kemper 2009). The pygmy right whale has been seen in oceanic as well as coastal environments, and it may move farther inshore in spring and summer based on food availability (Kemper 2009). Little is known regarding this species, because it is rarely seen at sea (Kemper 2009). The central and southern proposed survey areas are within its theoretical range, but it does not occur in northern Chile. One stranding record has been reported for Chile, on Chiloé Island, at 41.8°S (Cabrera et al. 2005). There are no records of this species in the OBIS or SIBIMAP databases (CPPS 2015; OBIS 2015).

Humpback Whale (*Megaptera novaeangliae*)

The humpback whale is found throughout all oceans of the world (Clapham 2009), with recent genetic evidence suggesting three separate subspecies: North Pacific, North Atlantic, and Southern Hemisphere (Jackson et al. 2014). The humpback whale is highly migratory, traveling between mid- to high-latitude waters where it feeds during spring to fall and low-latitude breeding grounds in winter

(Clapham 2009). Breeding grounds are in coastal areas, primarily in waters <200 m deep (e.g., Guidino et al. 2014), but migration routes can traverse deep pelagic areas (Félix and Guzmán 2014).

In the Southern Hemisphere, humpback whales migrate annually from summer foraging areas in the Antarctic to breeding grounds in tropical seas (Clapham 2009). The IWC recognizes seven breeding populations in the Southern Hemisphere that are linked to six foraging areas in the Antarctic (Clapham 2009). Humpback whales in the southeast Pacific belong to breeding stock 'G', with winter breeding grounds from June–September primarily off Columbia and Ecuador, to as far north as Panama and as far south as northern Peru; summer feeding grounds are found in the Antarctic and off Patagonian, Chile, as far north as 41°S (Felix and Haase 2001; Acevedo et al. 2013; Hucke-Gaete et al. 2013; Guidino et al. 2014). Bettridge et al. (2015) identified humpback whales at these breeding locations as the Southeastern Pacific DPS. Félix et al. (2011) estimated the southeast Pacific stock to number 6504 individuals.

The northern and central proposed survey areas lie between the winter breeding grounds and summer feeding grounds of the humpback whale. The southern end of the southern proposed survey area overlaps with a feeding ground located at ~41.5–44°S (Hucke-Gaete et al. 2013). Humpback whales are generally expected to be migrating northward during austral fall, but they have been seen in this area in feeding groups and mother–calf pairs primarily during austral summer/fall. Most sightings are in Corcovado Gulf, but some sightings were made offshore of Chiloé Island. Wood et al. (2015) also detected humpback whale calls in the Chiloé-Corcovado region during January 2012 to April 2013.

The migratory corridors of humpback whales are not well described in this region, but one study that combined satellite-tracking with SIBIMAP data showed that migration routes from Ecuador to the Antarctic could be both coastal and oceanic (up to 800 km offshore), with mothers with calves preferring more coastal routes (Félix and Guzmán 2014). Although the satellite tracking data were collected during the southward migration, sighting data suggested that the migration corridor is likely to be the same for both the southward and northward migrations (Félix and Guzmán 2014). Félix and Guzmán (2014) showed a cluster of sightings near the coast between ~29°S and 38°S during the northward migration (February–August); most offshore sightings were made near the Juan Fernández Islands.

CPPS (2014) reviewed 3599 records of this species in the SIBIMAP database during 1963–2010 and confirmed a primarily coastal migratory route along the South American coast with some individuals seen farther offshore, suggesting either a wide migration corridor or that some animals choose a more oceanic route. There are no records of this species in the OBIS database for the northern proposed survey area, but there are 5 and 37 historical whaling records within the central and southern proposed survey areas, respectively (Townsend 1935 *in* OBIS 2015).

Common Minke Whale (*Balaenoptera acutorostrata*)

The common minke whale has a cosmopolitan distribution ranging from the tropics and subtropics to the ice edge in both hemispheres (Jefferson et al. 2008). A smaller form (unnamed subspecies) of the common minke whale, known as the dwarf minke whale, occurs in the Southern Hemisphere, where its distribution overlaps with that of the Antarctic minke whale (B. bonaerensis) during summer (Perrin and Brownell 2009). The dwarf minke whale is generally found in shallower coastal waters and over the shelf in regions where it overlaps with the Antarctic minke whale (Perrin and Brownell 2009). The range of the dwarf minke whale is thought to extend as far south as 65°S (Jefferson et al. 2008) and as far north as 11°S in the western Pacific, 2°S off the Atlantic coast of South America, and Chile in the southeast Pacific (Perrin and Brownell 2009).

Although the theoretical range of the dwarf minke whale extends into the northern proposed survey area (Jefferson et al. 2008), there is a lack of sightings there. Capella et al. (1999) reported 2 sightings of

3 common minke whales near Chañaral Island in the Humboldt Penguin National Reserve, ~100 km north of the central proposed survey area; both sightings occurred during summer (January 1995). There are 4 records of common minke whale in the OBIS database for Chile, including 2 just to the north (29.0°S) of the central proposed survey area and 2 within the southern proposed survey area (Reyes 2006 *in* OBIS 2015). There were no records for the proposed survey areas in the SIBIMAP database (CPPS 2015).

Antarctic Minke Whale (*Balaenoptera bonaerensis*)

The Antarctic minke whale has a circumpolar distribution in coastal and offshore areas of the Southern Hemisphere from ~7°S to the ice edge (Jefferson et al. 2008). It is found between 60°S and the ice edge during the austral summer; in the austral winter, it is mainly found at mid-latitude breeding grounds. The South Pacific breeding ground is found in oceanic waters at 10–30°S, 170°E–100°W (Perrin and Brownell 2009).

Aguayo-Lobo et al. (1998) reported the northernmost occurrence of Antarctic minke whales at 23°S. Although the range of the Antarctic minke whale is thought to extend into the northern proposed survey area (Jefferson et al. 2008), there is a lack of sightings there. However, Aguayo et al. (1998) reported a relative abundance of 0.4/day for June–July 1995 between 26.3°S and 33.1°S. There are no records for the proposed survey areas in the OBIS or SIBIMAP databases (CPPS 2015; OBIS 2015).

Bryde's Whale (*Balaenoptera edeni/brydei*)

Bryde's whale occurs in all tropical and warm temperate waters in the Pacific, Atlantic, and Indian oceans, between 40°N and 40°S (Kato and Perrin 2009). In the southeast Pacific it occurs from the Equator to ~37°S. It is one of the least known large baleen whales, and its taxonomy is still under debate (Kato and Perrin 2009). B. brydei is commonly used to refer to the larger form or "true" Bryde's whale and B. edeni to the smaller form; however, some authors apply the name B. edeni to both forms (Kato and Perrin 2009; Rudolph and Smeenk 2009). The smaller form is restricted to coastal waters (Rudolph and Smeenk 2009). A recent genetic analysis suggests that Bryde's whales found off both coasts of South America belong to B. brydei, according to the classification of Wada et al. (2003), and showed genetic distinctiveness between South Pacific and South Atlantic Bryde's whales but no genetic difference between whales off Chile and Peru (Pastene et al. 2015). Although there is a pattern of movement toward the Equator in the winter and the poles during the summer, Bryde's whale does not undergo long seasonal migrations but rather remains in warm (>16°C) water year-round (Kato and Perrin 2009). Genetic evidence from the eastern South Pacific is consistent with a north to south movement of whales from the same population in the spring and summer (Pastene et al. 2015). Bryde's whale is frequently observed in biologically productive areas such as continental shelf breaks (e.g., Davis et al. 2002) and regions subjected to coastal upwelling (e.g., Gallardo et al. 1983; Siciliano et al. 2004).

CPPS (2014) examined 399 Bryde's whale records in the SIBIMAP database for 1963–2010 and confirmed that it does not undertake major north/south migrations, but that it may undertake important movements related to varying environmental conditions such as El Niño. Environmental modeling confirmed suitable habitat in the Southern Hemisphere year-round, mainly off Peru and out to the Galápagos Islands but extending into Chilean waters. During summer (December–May), there was a large area of suitable habitat as well as many sightings off south-central Chile, suggesting that the species may be distributed farther south during austral summer.

Aguayo-Lobo et al. (1998) reported that Bryde's whales occur in Chilean waters between 20°S and 36°S, with greater abundance in the north. They compiled 70 records (91 animals) for the northern region of Chile and 21 records (33 animals) for the central region, many of which were within the northern and central/southern proposed survey areas, respectively. Reported relative abundance estimates were 2.3–

2.6/day between 20.2°S and 32.2°S and 0.5/day between 32.2°S and 40°S from the SOWER sighting survey in December 1997–January 1998. There are 35 records of this species in the SIBIMAP database for Chile (CPPS 2015), many of which are in the northern proposed survey area. That database also includes one record of this species south of Chiloé Island at ~43.8°S. Although there are records of Bryde's whale in the OBIS database in the southeast Pacific, there are no records for Chile (OBIS 2015).

Sei Whale (*Balaenoptera borealis*)

The sei whale occurs in all ocean basins and is primarily an oceanic species (Horwood 2009). It undertakes seasonal migrations to feed in subpolar latitudes during summer and returns to lower latitudes during winter to calve (Horwood 2009). In the Southern Hemisphere, the sei whale typically concentrates between the Subtropical and Antarctic convergences during summer (Horwood 2009). It has been observed feeding in association with blue whales northwest of Chiloé Island in February and March (Galletti Vernazzani et al. 2005). Exact locations of its breeding and calving grounds are not known. The sei whales likely would be migrating northward to calving grounds during austral fall.

Aguayo-Lobo et al. (1998) compiled 4 records (4 animals) of sei whales in the northern region of Chile, 15 records (18 animals) in the central region, and 2 records (3 animals) in the southern region since the end of commercial whaling in 1982. Relative abundance estimates were 0.1–0.2/day between 20.2°S and 32.2°S and 1.1/day between 32.2°S and 40°S from the December 1997–January 1998 SOWER survey. Aguayo et al. (1998) reported a relative abundance of 0.1/day between 26.3°S and 33.1°S for May 1994. Wood et al. (2015) detected a possible sei whale during acoustic recordings in the Chiloé-Corcovado region during January 2012 to April 2013. There is one sei whale record in the OBIS database within the southern proposed survey area (Reyes 2006 *in* OBIS 2015), but there are no records for the other two proposed survey areas. There are 34 records of sei whales in the SIBIMAP database (CPPS 2015), all between 30.4°S and 44°S.

A recent (April–June 2015) mass stranding or strandings of sei whales was reported for the area between the Gulf of Penas and Puerto Natales (~47–52°S) in southern Chile (CBC News 2015), south of the southern proposed survey area. Thirty-seven sei whales were found dead on the beach in April, and 337 whales believed to be sei whales, including 32 skeletons, were seen during an observation flight in June. Although the cause of death has not been determined, human intervention was ruled out.

Fin Whale (*Balaenoptera physalus*)

The fin whale is widely distributed in all the world's oceans (Gambell 1985), although it is most abundant in temperate and cold waters (Aguilar 2009). Nonetheless, its overall range and distribution are not well known (Jefferson et al. 2008). The fin whale most commonly occurs offshore, but can also be found in coastal areas (Aguilar 2009). Most populations migrate seasonally between temperate waters where mating and calving occur in winter, and polar waters where feeding occurs in summer (Aguilar 2009). However, recent evidence suggests that some animals may remain at high latitudes in winter or low latitudes in summer (Edwards et al. 2015). The fin whale is known to use the shelf edge as a migration route (Evans 1987). Sergeant (1977) suggested that fin whales tend to follow steep slope contours, either because they detect them readily, or because the contours are areas of high biological productivity. However, fin whale movements have been reported to be complex, and not all populations follow this simple pattern (Jefferson et al. 2008).

In the Southern Hemisphere, fin whales are typically distributed south of 50ºS in austral summer, and they migrate northward to breed in winter (Gambell 1985). The distribution of fin whales in the proposed survey areas is not well known. A recent analysis of fin whale abundance globally suggests that there may be a hiatus in fin whale distribution in tropical waters, with the northern proposed survey area falling at the northernmost end of their distribution (Edwards et al. 2015). Recent studies have shown fin whales feeding near the coast in northern Chile at 23°S during July–October in waters 30–1000 m deep (Pacheco et al. 2015) and near Chañaral Island (29°S) at the Humboldt Penguin National Reserve (Perez et al. 2006).

Aguayo-Lobo et al. (1998) compiled 3 records of 7, 15 records of 31, and 2 records of 3 fin whales for the northern, central, and southern regions of Chile, respectively, since the end of commercial whaling in 1982. Relative abundances were 0.1/day between 20.2°S and 32.2°S and 1.1/day between 32.2°S and 40°S from the December 1997–January 1998 SOWER survey. Aguayo et al. (1998) reported a relative abundance estimate of 0.8/day between 26.3°S and 33.1°S for June–July. Capella et al. (1999) reported 9 sightings (28 animals) of fin whales near Chañaral Island (~29.0°S, 71.6°W) in the Humboldt Penguin National Reserve; those occurred during summer (January 1995 and February 1993) and fall (April 1994). These sightings are also in the OBIS database (Reyes 2006 *in* OBIS 2015); there are 3 additional sightings in the OBIS database for the southern proposed survey area. In the SIBIMAP database, there are 8 records of fin whales for Chile (CPPS 2015), 7 of which are within the southern proposed survey area, and the other is ~130 km offshore from the central proposed survey area. SIO (2012) reported 13 sightings of 35 fin whales in the northern portion of the southern proposed survey area.

Blue Whale (*Balaenoptera musculus*)

The blue whale has a cosmopolitan distribution, but tends to be mostly pelagic, only occurring nearshore to feed and possibly breed (Jefferson et al. 2008). There are two subspecies in the Southern Hemisphere: *B.m. intermedia* (the true blue whale) in the Antarctic and *B.m. brevicauda* (the pygmy blue whale) in the sub-Antarctic zone (Sears and Perrin 2009). The Antarctic blue whale is typically found south of 55°S during summer, although some are known not to migrate (Branch et al. 2007). Blue whale migration is less well defined than some of the other rorquals, and their movements tend to be more closely linked to areas of high primary productivity, and hence prey, to meet their high energetic demands (Branch et al. 2007; CPPS 2014). Branch et al. (2007) reported that blue whale sighting rates were high in the southeast Pacific relative to the Antarctic; Chile was among the locations with the highest sighting rates.

A large feeding aggregation area for this species occurs in waters between 39°S and 44°S during February–April (Hucke-Gaete et al. 2004; Galletti Vernazzani et al. 2012). Passive acoustic monitoring shows blue whales to be present in the Chiloé-Corcovado region (~43°S–44°S, 71°W–73°W) from December to August with a peak during March–May, and supports movement toward the ETP during June and July (Buchan et al. 2015; Wood et al. 2015). Genetic evidence suggests that blue whales from southern and central Chile and the ETP are from the same breeding population, which is distinct from that of the Antarctic (Torres-Florez et al. 2014). Antarctic blue whale calls were also detected in the Chiloé-Corcovado region during the austral summer as they passed through the area (Wood et al. 2015).

Aguayo-Lobo et al. (1998) considered the two subspecies of blue whale (B. m. intermedia and B.m. brevicauda) separately. They compiled 2 records of 2, 2 records of 3, and 1 record of 1 B.m. intermedia for the northern, central, and southern regions of Chile, respectively, since the end of commercial whaling in the region in 1982. Relative abundances were 0.1–0.2/day between 20.2°S and 32.2°S and 0.1/day between 32.2°S and 40°S from the SOWER survey in December 1997–January 1998. Aguayo et al. (1998) reported a relative abundance of 0.3/day between 26.3°S and 33.1°S for June–July. Aguayo-Lobo et al. (1998) reported 26 sightings of 34, 11 sightings of 11, and 1 sighting of 1 B.m. brevicauda for the northern, central, and southern regions of Chile, respectively; relative abundance estimates were 1.1–1.2/day between 20.2°S and 32.2°S, 0.6/day between 32.2°S and 40°S, and 0.3/day between 40°S and 53°S from the December 1997–January 1998 SOWER survey. Williams et al. (2011)

used spatial modeling to calculate an abundance estimate of 303 blue whales for the SOWER survey area. The average reported relative abundance from 8 years of aerial surveys during February to April between 39°S–44°S and out to 37 km was 31.7 groups/1000 km, with a maximum of 169.4 groups/1000 km northwest of Chiloé Island (Galletti Vernazzani et al. 2012).

There are 234 sightings of blue whales in the SIBIMAP database for Chile, occurring along the length of the Chilean coast (CPPS 2015); 2 of these are near the northern proposed survey area and several are within the central and southern proposed survey areas. CPPS (2014) considered 596 blue whale sightings in the SIBIMAP database from 1963–2010 and found evidence of movement from the south of Chile off Chiloé Island, where they feed during austral fall, northward along the Humboldt Current upwelling to Chile and Peru. Although there are records of this species in the OBIS database for the southeast Pacific, there are no records for Chile (OBIS 2015).

Odontocetes

Sperm Whale (*Physeter macrocephalus*)

The sperm whale is the largest of the toothed whales, with an extensive worldwide distribution from the edge of the polar pack ice to the Equator in both hemispheres where depths are >1000 m (Whitehead 2009). Sperm whale distribution is linked to their social structure: mixed groups of adult females and juveniles of both sexes generally occur in tropical and subtropical waters at latitudes less than ~40° (Whitehead 2009). After leaving their female relatives, males gradually move to higher latitudes with the largest males occurring at the highest latitudes and only returning to tropical and subtropical regions to breed.

Until 1982, sperm whales were hunted heavily all along the coast of Chile and out to ~110°W. Since that time, most sightings have been in the northern region of Chile, but sperm whales occur all the way south to the Drake Passage (Aguayo-Lobo et al. 1998). Sixty-three sightings of 266, 53 records of 163, and 13 records of 18 were compiled for the northern, central, and southern regions of Chile, respectively, since the end of the commercial hunt in 1982. Reported relative abundances were 2.3–11.1/day between 20.2°S and 32.2°S, 4.4/day between 32.2°S and 40°S, and 1.7/day between 40°S and 53°S from a sighting survey in December 1997–January 1998. Aguayo et al. (1998) reported relative abundances of 0.3/day and 1.9/day between 26.3°S and 33.1°S for May 1995 and June–July 1995, respectively.

Rendell et al. (2004) spent 8 months in 2000 (April–December) following sperm whales, both visually and acoustically, off Chile between 18.5°S and 25°S; encounter rates were higher south of 22.5°S, coinciding with upwelling in that region. There are numerous records of sperm whales from the proposed survey areas in the OBIS and SIBIMAP databases (CPPS 2015; OBIS 2015), primarily because they contain American whaling logbook records and sightings from focused sperm whale research, respectively, suggesting that sperm whales are common in the area both historically and currently. CPPS (2014) examined 6863 records in the SIBIMAP database during 1963–2010 and found that sperm whales were widely distributed throughout the southeast Pacific with major concentrations in areas of high primary productivity, including along the Humboldt Current. SIO (2012) reported a group of 2 in the northern portion of the southern proposed survey area.

Dwarf (*Kogia sima*) and Pygmy (*K. breviceps*) Sperm Whales

The dwarf and pygmy sperm whales are distributed widely throughout tropical and temperate seas, but their precise distributions are unknown because much of what we know of the species comes from strandings (McAlpine 2009). They are difficult to sight at sea, because of their dive behavior and perhaps because of their avoidance reactions to ships and behavior changes in relation to survey aircraft (Würsig et al. 1998). The two species are often difficult to distinguish from one another when sighted, but dwarf sperm whales may be more pelagic with a preference for deeper water (McAlpine 2009).

Both Kogia species are sighted primarily along the continental shelf edge and slope and over deeper waters off the shelf (Hansen et al. 1994; Davis et al. 1998; Jefferson et al. 2008). Several studies have suggested that pygmy sperm whales live mostly beyond the continental shelf edge, whereas dwarf sperm whales tend to occur closer to shore, often over the continental shelf (Rice 1998; Wang et al. 2002; MacLeod et al. 2004). Barros et al. (1998), on the other hand, suggested that dwarf sperm whales could be more pelagic and dive deeper than pygmy sperm whales. It has also been suggested that the pygmy sperm whale is more temperate and the dwarf sperm whale more tropical, based at least partially on live sightings at sea from a large database from the ETP (Wade and Gerrodette 1993). This idea is also supported by the distribution of strandings in South American waters (Muñoz-Hincapié et al. 1998).

Aguayo-Lobo et al. (1998) reported no records of dwarf sperm whales in the northern region of Chile, but one occurrence of an individual pygmy sperm whale, which was sighted near Iquique (20.2°S) in the northern proposed survey area. Aguayo-Lobo et al. (1998) also compiled 2 sightings of pygmy sperm whales and 3 sightings of dwarf sperm whales in the central region of Chile (32–40°S). One dwarf sperm whale sighting occurred near Valparaíso at 33.1°S in the central proposed survey area. They found no records of either species in southern Chile. There are no records of either species for the proposed survey areas in the OBIS or SIBIMAP databases (CPPS 2015). In the OBIS database, there are 2 records of pygmy sperm whales for the southern proposed survey area; there no records of dwarf sperm whales for any of the proposed survey areas (OBIS 2015).

Cuvier’s Beaked Whale (*Ziphius cavirostris*)

Cuvier’s beaked whale is the most widespread of the beaked whales, occurring in almost all temperate, subtropical, and tropical waters and even some sub-polar and polar ones (MacLeod et al. 2006). It is likely the most abundant of all beaked whales (Heyning and Mead 2009). Cuvier’s beaked whale is found in deep water over and near the continental slope (Gannier and Epinat 2008; Jefferson et al. 2008).

Aguayo-Lobo et al. (1998) reported 4 sightings of 6, 6 sightings of 31, and 3 sightings of 3 for the northern, central, and southern regions of Chile, respectively; some of those sightings occurred in the central proposed survey area. Reported relative abundances were 2.0/day between 32°S and 47°S for March–April 1966 and 0-0.2/day between 20.2°S and 53°S for December 1997–January 1998 (Aguayo-Lobo et al. (1998), and 0.1/day between 26.3°S and 33.1°S for May 1994 (Aguayo et al. 1998). The SIBIMAP database has one sighting of a Cuvier's beaked whale near the central proposed survey area at 30.5°S, 73.7°W (CPPS 2015). There are no records of Cuvier’s beaked whale in the OBIS (2015) database for the proposed survey areas.

Shepherd’s Beaked Whale (*Tasmacetus shepherdi*)

Based on known records, it is likely that Shepherd’s beaked whale has a circumpolar distribution in the cold temperate waters of the Southern Hemisphere (Mead 1989). It is primarily known from strandings, most of which have been recorded in New Zealand (Pitman et al. 2006; Mead 2009). However, two strandings have occurred on the Juan Fernández Islands (Pitman et al. 2006; Mead 2009), which are located ~520 km west of the southern end of the central proposed survey area. There are no records of Shepherd’s beaked whale for Chile in the OBIS or SIBIMAP databases (CPPS 2015; OBIS 2015).

Southern Bottlenose Whale (*Hyperoodon planifrons*)

The southern bottlenose whale can be found throughout the Southern Hemisphere from 30°S to the ice edge (Gowans 2009). Although it is not expected to occur in the waters of northern Chile, sightings have been made off central and southern Chile (MacLeod et al. 2006). Little is known about this species, because it is not well studied and there are no known areas of concentration (Gowans 2009).

Aguayo-Lobo et al. (1998) compiled 6 records of 23 and 8 records of 11 for the central and southern regions of Chile, respectively, including some within the central and southern proposed survey areas. Relative abundance estimates were 1.4, 0.1, and 2.3/day for March–April, October, and December of 1966, respectively, between 32°S and 47°S, and 0.27/day for February of 1982 between 32°S and 38.5°S (Aguayo-Lobo et al. 1998). The SIBIMAP database contains two records for Chile (CPPS 2015), including one just west of the central proposed survey area at 31.3°S, 73.4°W, and one offshore of the southern proposed survey area at ~34.1°S, 74.9°W. There are no records of southern bottlenose whales for Chile in the OBIS database (OBIS 2015).

Hector's Beaked Whale (*Mesoplodon hectori*)

Hector's beaked whale is thought to have a circumpolar distribution in temperate waters of the Southern Hemisphere (Pitman 2009). Based on the number of stranding records for this species, it appears to be quite rare. There are no records in the South Pacific between New Zealand and South America, but it is not clear if this is a gap in distribution or related to a lack of sighting effort (MacLeod et al. 2006). On the Atlantic coast of South America, it occurs as far north as 32°S off Brazil, and in the southwest Pacific, it occurs as far north as 35.2°S (MacLeod et al. 2006).

Gray's Beaked Whale (*Mesoplodon grayi*)

Gray's beaked whale is thought to have a circumpolar distribution in temperate waters of the Southern Hemisphere (Pitman 2009). In the southeast Pacific it is thought to occur from the Antarctic to central Peru, with the cold waters of the Humboldt Current likely enabling it to occur so far north (MacLeod et al. 2006). Aguayo-Lobo et al. (1998) reported no occurrences of Gray's beaked whale for northern or central Chile, and 3 records in the southern region, all south of 50°S. Aguayo-Lobo et al. (1998) also reported 16 records of 41, 2 records of 8, and 2 records of 5 unidentified mesoplodont whales for the northern, central, and southern regions of Chile, respectively; some of those could have been Gray's beaked whales. There are no records of Gray's beaked whale for Chile in the OBIS or SIBIMAP databases (CPPS 2015; OBIS 2015).

Pygmy Beaked Whale (*Mesoplodon peruvianus*)

The pygmy beaked whale is thought to occur mostly in tropical waters in the eastern Pacific (Pitman 2009). In Chile, strandings have occurred as far south as 29.2°S (MacLeod et al. 2006). It is likely that this species is the beaked whale previously known as Mesoplodon sp. "A" in the ETP (Pitman and Lynn 2001 in MacLeod et al. 2006). Aguayo-Lobo et al. (1998) compiled 4 records for the northern region of Chile, consisting of 3 sightings and 1 skull, and none for the central or southern regions; all records were near the Humboldt Penguin National Reserve (29°S). Aguayo-Lobo et al. (1998) also reported 16 records of 41 unidentified mesoplodont whales in northern Chile within the northern proposed survey area; some of these could have been pygmy beaked whales. Because this is primarily a tropical species, any sighting within the central or southern proposed survey areas would be extralimital. There are no records of the pygmy beaked whale for any of the proposed survey areas in either the OBIS or SIBIMAP databases (CPPS 2015; OBIS 2015).

Andrew's Beaked Whale (*Mesoplodon bowdoini*)

Andrew's beaked whale likely has a circumpolar distribution in temperate waters of the Southern Hemisphere (Baker 2001; Pitman 2009). Its range in the southwest Pacific is probably between 54.5°S and 32°S (Baker 2001). There are no records of this species along the west coast of South America, but it is unknown if this is a true gap in distribution or a general lack of information for that area (MacLeod et al. 2006).

Strap-toothed Whale (*Mesoplodon layardii*)

The strap-toothed whale is thought to have a circumpolar distribution in temperate and sub-Antarctic waters of the Southern Hemisphere, mostly between 32°S and 63°S (MacLeod et al. 2006; Jefferson et al. 2008). Based on the seasonality of stranding records, the strap-toothed whale likely undertakes a limited migration northward from Antarctic and sub-Antarctic latitudes during austral winter (Pitman 2009). There is an absence of records of this species from the west coast of South America, but the central and southern proposed survey areas are within its theoretical range (Jefferson et al. 2008).

Spade-toothed Whale (*Mesoplodon traversii*)

The spade-toothed beaked whale is the name proposed for the species formerly known as Bahamonde's beaked whale (M. bahamondi); genetic evidence has shown that it belongs to the species first identified by Gray in 1874 (van Helden et al. 2002). The spade-toothed beaked whale is considered relatively rare and is known from only four records, three from New Zealand and one from the Juan Fernández Islands, Chile (Thompson et al. 2012). The Juan Fernández Islands are located ~520 km west of the southern end of the central proposed survey area.

Blainville's Beaked Whale (*Mesoplodon densirostris*)

Blainville's beaked whale is found in tropical and warm temperate waters of all oceans; it has the widest distribution throughout the world of all mesoplodont species and appears to be common (Pitman 2009). In the southeast Pacific, it is thought to occur as far south as ~45°S (MacLeod et al. 2006). Aguayo-Lobo et al. (1998) found no occurrences of Blainville's beaked whales in either the northern or central regions of Chile, and only one record in the southern region, northwest of Chiloé Island; there was also one record from Easter Island. Aguayo-Lobo et al. (1998) also reported 16 records of 41, 2 records of 8, and 2 records of 5 unidentified mesoplodont whales for the northern, central, and southern regions of Chile, respectively; it is likely that many of those were Blainville's beaked whales. Several of the sightings were in the northern proposed survey area and one was in the central proposed survey area. There are no records of Blainville's beaked whale for any of the proposed survey areas in the SIBIMAP database (CPPS 2015). There is one record of a Blainville's beaked whale in the OBIS database for the southern proposed survey area at 36.5°S, 74°W (Reyes 2006 *in* OBIS 2015).

Chilean Dolphin (*Cephalorhynchus eutropia*)

The Chilean dolphin is found along the Chilean coast from Valparaíso to Cape Horn (Dawson 2009). The northernmost sighting of this species has been reported for ~32°S (Goodall et al. 1988). Although its range is not well known, it is generally thought to be restricted to shallow coastal waters with strong currents (Heinrich 2006). A 4-y study along the east coast of Chiloé Island in southern Chile resulted in a population size estimate of 73 for south Chiloé and 59 for central Chiloé during 2001–2004 (Heinrich 2006).

Aguayo-Lobo et al. (1998) compiled 221 records of 1229 for the central region of Chile and 56 records of 319 for the southern region. They reported relative abundances of 6.7/day for the waters between Concepción (36.7°S) and Valdivia (39.8°S), within the southern proposed survey area, and

1.13/day between Chiloé (41°S) and Navarino (55°SS). The Chilean dolphin is not expected to occur as far north as the northern proposed survey area. There are no records of Chilean dolphin in the OBIS or SIBIMAP databases (CPPS 2015; OBIS 2015).

Rough-toothed Dolphin (*Steno bredanensis*)

The rough-toothed dolphin is distributed worldwide in tropical to warm temperate oceanic waters (Miyazaki and Perrin 1994; Jefferson 2009). In the southeast Pacific, its range may extend as far south as northern Chile (Jefferson et al. 2008), with the northern proposed survey area being at the southern end of its range and the central proposed survey area outside its known range.

Aguayo-Lobo et al. (1998) reported only a single occurrence of a rough-toothed dolphin in Chilean waters, at 24.5°S, but suggested that individuals of this species likely travel from Peruvian waters into this region in search of food, particularly during El Niño years. There are no records within any of the proposed survey areas in the OBIS or SIBIMAP databases (CPPS 2015; OBIS 2015).

Common Bottlenose Dolphin (*Tursiops truncatus*)

The bottlenose dolphin occurs in tropical, subtropical, and temperate waters throughout the world (Wells and Scott 2009). In the southeast Pacific, it is generally seen from northern Chile to ~40°S with records as far south as the Magellan Strait (Olavarría et al. 2010). In many parts of the world, coastal and offshore ecotypes have been distinguished based on morphological, ecological, and physiological features (Jefferson et al. 2008). Whereas both the coastal and offshore forms are present in Chilean waters, the offshore form is more abundant (Sanino and Van Waerebeek 2008).

Aguayo-Lobo et al. (1998) reported 56 sightings of 5942, 14 sightings of 565, and no sightings of common bottlenose dolphins for the northern, central, and southern regions of Chile, respectively. Relative abundances were 135.0–309.2/day between 20.2°S and 32.2°S and 2.7–21.3/day between 32.2°S and 40°S from a sighting survey in December 1997–January 1998. Aguayo et al. (1998) reported relative abundances of 1.1 and 1.9/day between 26.3°S and 33.1°S for May 1994 and June–July 1995, respectively.

Capella et al. (1999) reported 9 sightings of a total of ~193–253 common bottlenose dolphins in the waters near Chañaral Island in the Humboldt Penguin National Reserve. This was the only species sighted there during all four seasons, with sightings during January, March, April, July, November, and December; there was no sighting effort in May or June. One of the sightings, in November 1991, was of a large mixed-species group of 170–230 common bottlenose dolphins and 100–140 long-finned pilot whales. Similarly, Pérez-Alvarez et al. (2015) reported a small resident population at Isla Chañaral and Isla Choros-Damas marine protected areas. Diaz-Aguirre et al. (2009) also reported the year-round presence of common bottlenose dolphins in central Chile from Punta Angeles (33.0°S) to Punta Gallo (33.2°S). Olavarría et al. (2010) compiled 28 sightings between 41.8°S and 45.8°S; sightings were reported from all months of the year except June and September.

In a study of drift gillnet and longline bycatch in northern Peru, common bottlenose dolphins constituted 13% of the recorded cetacean bycatch (Mangel et al. 2008). There are 55 records from Chile in the SIBIMAP database (CPPS 2015), including 2 in the northern proposed survey area and several in and around the central and southern proposed survey areas. There are 9 records in the OBIS database for the central proposed survey area, all around Chañaral Island; there are no records for the northern or southern proposed survey areas (OBIS 2015).

Striped Dolphin (*Stenella coeruleoalba*)

The striped dolphin has a cosmopolitan distribution in tropical to warm temperate waters from ~50°N to 40°S (Perrin et al. 1994; Jefferson et al. 2008). It occurs primarily in pelagic waters, but has been observed approaching shore where there is deep water close to the coast (Jefferson et al. 2008).

Aguayo-Lobo et al. (1998) reported 1 sighting of 60 striped dolphins in the northern region of Chile in the waters off Iquique (20.2°S) during the 1997–1998 SOWER survey. There is only one record for Chile in the SIBIMAP database, near Robinson Crusoe Island in central Chile (CPPS 2015). There are no records in the OBIS database for the proposed survey areas (OBIS 2015).

Short-beaked (*Delphinus delphis*) and Long-beaked (*D. capensis*) Common Dolphin

The common dolphin can be found in tropical and warm temperate oceans around the world (Perrin 2009). In general, the long-beaked common dolphin seems to prefer shallower, warmer water and occurs closer to the coast (Perrin 2009). In the southeast Pacific, the long-beaked common dolphin is distributed from northern Peru to northern Chile, whereas the short-beaked common dolphin occurs continuously as far south as central Chile; thus, the two species overlap in distribution off northern Chile, but only the short-beaked common dolphin occurs off central Chile (Perrin 2009). In a study of drift gillnet and longline bycatch in northern Peru, the common dolphin was the most frequently observed cetacean, constituting 47% of the recorded bycatch (Mangel et al. 2008).

Aguayo-Lobo et al. (1998) compiled 9 sightings of 908, 10 sightings of 1732, and 1 sighting of 2 short-beaked common dolphins for the northern, central, and southern regions of Chile, respectively. Estimated relative abundances were 5.0–27.5/day between 20.2°S and 32.2°S and 0.1/day between 32.2°S and 40°S from a sighting survey in December 1997–January 1998 (Aguayo-Lobo et al. 1998). Estimated relative abundances between 26.3°S and 33.1°S were 0.8, 10.8, and 3.2/day for September 1993, 1994, and 1995, respectively, 193.0/day for May 1994, and 5.1/day for June–July 1995 (Aguayo et al. 1998). There is one record of short-beaked common dolphins in the SIBIMAP database at 30°S, 72.5°W, within the central proposed survey area at ~30°S, 72.5°W, one record within the southern proposed survey area at ~36.1°S, 74.1°W, and several farther offshore from those areas. There are no records in the OBIS database for the proposed survey areas (OBIS 2015).

For long-beaked common dolphins, Aguayo-Lobo et al. (1998) reported 2 sightings of 301 animals in northern Chile; one sighting was of 300 in the waters off Iquique (20.2°S) from the December 1997–January 1998 SOWER survey. There are no records of long-beaked common dolphins for the proposed survey areas in the OBIS or SIBIMAP databases (CPPS 2015; OBIS 2015).

Dusky Dolphin (*Lagenorhynchus obscurus*)

The dusky dolphin occurs throughout the Southern Hemisphere primarily over continental shelves and slopes, but it is sometimes found over deep water close to continents or islands (Van Waerebeek and Würsig 2009). Along the west coast of South America, it is present from northern Peru to Cape Horn. In the southeast Pacific, it is primarily limited to within ~90 km from shore (Van Waerebeek 1992). The dusky dolphin is commonly seen in Peruvian coastal waters in large feeding aggregations of many hundreds or thousands in association with the common dolphin (Van Waerebeek and Würsig 2009).

Dusky dolphins are common in northern Chile, where they have been hunted for human consumption and incidentally caught in the gillnet fisheries, and in southern Chile, where they were hunted for bait in the crab fishery (Aguayo-Lobo et al. 1998). Aguayo-Lobo et al. (1998) reported 37 sightings of 1076 animals, 39 sightings of 492, and 30 sightings of 1117 dusky dolphins in the northern, central, and southern regions of Chile, respectively, many of which were in the proposed survey areas.

Reported relative abundances were 7.9–22.5/day between 20.2°S and 32.2°S and 0.1/day between 32.2°S and 40°S, from a sighting survey in December 1997–January 1998. Aguayo et al. (1998) reported a relative abundance of 0.3/day between 26.3°S and 33.1°S during June–July 1995.

Dusky dolphins were the most frequently sighted cetacean by Capella et al. (1999) in the waters near Chañaral Island in the Humboldt Penguin National Reserve, with 8 sightings of ~1310–1750; group size estimates were 50–450. Dusky dolphins were sighted there during summer (January 1995 and February 1990 and 1993) and fall (April 1991 and 1994) (Capella et al. 1999).

In a study of drift gillnet and longline bycatch in northern Peru, dusky dolphins constituted 29% of the recorded cetacean bycatch (Mangel et al. 2008). There are 6 records in the SIBIMAP database (CPPS 2015), including two in the northern proposed survey area, one adjacent to the central proposed survey area, and two in the southern proposed survey area. There are 8 records in the OBIS database near the central proposed survey area, all around Chañaral Island, and 7 records in the southern proposed survey area; there are no records for the northern proposed survey area (OBIS 2015).

Peale's Dolphin (*Lagenorhynchus australis*)

Peale's dolphin is a South American species that is common from ~59°S to ~39°S on the Pacific coast and to ~44°S on the Atlantic coast (Goodall 2009b). The northernmost record of this species in the eastern South Pacific is just north of Valparaíso, Chile, at 32.9°S (Goodall et al. 1997b); thus, Peale's dolphin is not expected to occur within the northern proposed survey area. Peale's dolphin is a coastal species, often found associated with kelp beds and in water <200 m deep (Heinrich 2006). A 4-y study along the east coast of Chiloé Island in southern Chile resulted in a mean local population size of 78 for south Chiloé and 123 for central Chiloé during 2001–2004 (Heinrich 2006).

Aguayo-Lobo et al. (1998) compiled 15 records of 36 Peale's dolphin for the central region of Chile, including some within the central proposed survey area, and 693 records of 2802 for southern Chile, including some within the southern proposed survey area. There are 28 records of this species in the OBIS database north of 44°S along the Chilean coast (Reyes 2006 *in* OBIS 2015); one of those, at 33.6°S, is within the central proposed survey area, five are within the southern proposed survey area, and the remainder are found farther inshore in the Corcovado Gulf and east of Chiloé Island. There are no records in the SIBIMAP database (CPPS 2015).

Hourglass Dolphin (*Lagenorhynchus cruciger*)

The hourglass dolphin occurs in all parts of the Southern Ocean, with most sightings between 45°S and 60°S (Goodall 2009a). Although it is pelagic, it is also sighted near banks and islands (Goodall 2009a). The northernmost sighting in the eastern South Pacific is of 8 individuals near Valparaíso, Chile, at 33.7°S (Goodall 1997); this is at the southern limit of the central proposed survey area. However, the lack of photographic evidence from that sighting (Aguayo et al. 1998), along with difficulty in distinguishing among Lagenorhynchus species at the time the sighting was made (Goodall et al. 1997a), and a lack of other sightings at this latitude suggest that this species is likely to be rare that far north. Aguayo-Lobo et al. (1998) reported 30 records of 99 hourglass dolphins for the southern region of Chile, all south of ~49°S. Thus, this species would not be encountered in the northern proposed survey area, and is expected to be rare at best in the central and southern proposed survey areas.

Southern Right Whale Dolphin (*Lissodelphis peronii*)

The southern right whale dolphin is distributed between the Subtropical and Antarctic convergences in the Southern Hemisphere (Jefferson et al. 1994). In the southeast Pacific, it is most often seen between 25°S and 55°S in offshore waters, but has been observed near the coast of Chile (Lipsky 2009). The northernmost record is 12°S off central Peru (Jefferson et al. 2008).

Southern right whale dolphins are generally less common off northern Chile than farther south (Aguayo-Lobo et al. 1998). Aguayo-Lobo et al. (1998) reported 14 sightings of 583, 21 sightings of 2095, and 35 sightings of 2533 for the northern, central, and southern regions of Chile, respectively. No relative abundance estimate was available for the northern region, but estimates of 0.4–5.0/day between 32.2°S and 40°S and 22.9–80/day between 40°S and 53°S were reported from a sighting survey in December 1997–January 1998; an estimate of 22.6/day was reported between 32°S and 47°S for March–April 1966 (Aguayo 1975 *in* Aguayo-Lobo et al. 1998).

There are 10 records of southern right whale dolphins for Chilean waters in the SIBIMAP database, including one within the central proposed survey area, and the remainder between 39.1°S and 45.2°S, including within the southern proposed survey area (CPPS 2015). In the OBIS database, there is one record for the southern proposed survey area at ~40°S, 74.2°; there are no records for the other proposed survey areas (OBIS 2015). SIO (2012) reported a group of 2 in the northern portion of the southern proposed survey area.

Risso's Dolphin (*Grampus griseus*)

Risso's dolphin is primarily a tropical and mid-temperate species distributed worldwide (Kruse et al. 1999). Although it occurs from coastal to deep water, it shows a strong preference for mid-temperate waters of the continental shelf and slope (Jefferson et al. 2014). Olavarría et al. (2001) reported that the occurrence of Risso's dolphin is continuous along the Chilean coast from ~20.2°S to 40°S, but that the majority of the records occurred in northern waters during austral summer; they seem to prefer waters >1000 m deep. Risso's dolphin is gregarious, with typical group sizes of 10–100 and a maximum group size of ~4000 (Jefferson et al. 2008).

Aguayo-Lobo et al. (1998) reported 25 sightings of 367, 9 sightings of 69, and 4 sightings of 4 Risso's dolphins for the northern, central, and southern regions of Chile, respectively. It was most common in northern Chile, with a relative abundance of 17.6/day between 20.2°S and 32.2°S from a sighting survey in December 1997–January of 1998; the relative abundance estimate for the central region was 0.5/day between 32.2°S and 40°S (Aguayo-Lobo et al. 1998).

There are 9 records in the OBIS database within the northern proposed survey area, all during December 1997; 6 records within the central proposed survey area, all during the summer except for one in July; and 7 records within the southern proposed survey area, during July and December (Reyes 2006 *in* OBIS 2015). There is only one record in the SIBIMAP database, within the central proposed survey area at 32.5°S (CPPS 2015).

Pygmy Killer Whale (*Feresa attenuata*)

The pygmy killer whale has a worldwide distribution in tropical and subtropical waters (Donahue and Perryman 2009), generally not ranging south of 35°S (Jefferson et al. 2008). It is known to inhabit the warm waters of the Indian, Pacific, and Atlantic oceans (Jefferson et al. 2008). It can be found in nearshore areas where the water is deep and in offshore waters (Jefferson et al. 2008). The pygmy killer whale is sighted frequently in the ETP (Donahue and Perryman 2009).

Aguayo-Lobo et al. (1998) reported only a single sighting of pygmy killer whales in Chilean waters, at 26°S, 73.2°W. The SIBIMAP database shows 15 records for Chilean waters; all are near the central and southern proposed survey areas (CPPS 2015). There are no records in the OBIS database (OBIS 2015).

False Killer Whale (*Pseudorca crassidens*)

The false killer whale is found in all tropical and warmer temperate oceans, especially in deep offshore waters (Odell and McClune 1999). It is primarily pelagic but can also be seen in shallow water near oceanic islands (Baird 2009). The false killer whale is widely distributed, but generally uncommon throughout its range (Baird 2009). It is gregarious and forms strong social bonds, as is evident from its propensity to strand en masse (Baird 2009). Its distribution along the Chilean coast is thought to be continuous throughout the northern and central regions (Flores et al. 2003).

Aguayo-Lobo et al. (1998) reported 4 sightings of 108 false killer whales in northern Chile, 3 of which were in the northern proposed survey area; one sighting was in each of the central and southern proposed survey areas. No relative abundance estimates were provided. The only record for Chile in the SIBIMAP database is from Easter Island (CPPS 2015). There are no records in the OBIS database for the proposed survey areas (OBIS 2015).

Killer Whale (*Orcinus orca*)

The killer whale is widely distributed in all oceans of the world, but is most common in temperate coastal waters (Ford 2009). It is very common in temperate waters but also occurs in tropical waters (Heyning and Dahlheim 1988), and it inhabits coastal as well as offshore regions (Budylenko 1981). It is thought to be rare throughout the ETP, eastern temperate Pacific, and eastern South Pacific (Forney and Wade 2006). However, sightings have been reported along the entire coast of Chile (Félix and Escobar 2011).

Aguayo-Lobo et al. (1998) reported 8 sightings of 18, 8 sightings of 35, and 13 sightings of 43 killer whales for the northern, central, and southern regions of Chile, respectively, including sightings in all three of the proposed survey areas. They reported relative abundance estimates of 0.4/day between 20.2°S and 32.2°S from a sighting survey in December 1997–January 1998 and 1.0/day between 32°S and 38.5°S from a survey in February of 1982. A relative abundance of 0.1/day was reported by Aguayo et al. (1998) between 26.3°S and 33.1°S for May 1994. Capella et al. (1999) reported 2 sightings near Chañaral Island in the Humboldt Penguin National Reserve: pods of 3 in November 1989 and 5 in July 1991; this was one of only 2 species sighted there during their limited winter surveys.

There are 78 records of killer whales in the SIBIMAP database (CPPS 2015), widely distributed along the coast of Chile, including all three of the proposed survey areas. In Peru, killer whales were sighted along the length of the country as far south as the border with Chile during Instituto del Mar del Peru (IMARPE) sighting surveys in 1995–2003, but sightings were rare (Garcia-Godos 2004). There is one record in the OBIS database in the southern proposed survey area at ~38.4°S, 73.4°W; there are no records for the northern or central proposed survey areas (OBIS 2015).

Short-finned (*Globicephala macrorhynchus*) and Long-finned (*G. melas*) Pilot Whales

The short-finned pilot whale is generally found in tropical and warm temperate waters, whereas the long-finned pilot whale is distributed antitropically in cold temperate waters, with little overlap between the two species (Olson 2009). However, the west coast of South America, off northern Chile and southern Peru, is one region where their ranges do overlap. Short-finned pilot whale distribution does not generally range south of 40°S (Jefferson et al. 2008).

Sanino and Yáñez (2001) reported that long-finned pilot whales were present along the entire coast of Chile, whereas short-finned pilot whales were restricted to the north and central regions. Pilot whales are very social and are usually seen in groups of 20–90 (Olson 2009). They can often be seen in mixed-species aggregations. Capella et al. (1999) reported sighting 100–140 long-finned pilot whales in association with 170–230 common bottlenose dolphins 8 km northwest of Chañaral Island in the Humboldt Penguin National Reserve in November 1991.

Aguayo-Lobo et al. (1998) reported 4 sightings of 4 short-finned pilot whales in the northern region of Chile, one of which was at the southern end of the proposed survey area, but no sightings were made for the central or southern regions of Chile; relative abundance estimates were not available. They also reported 24 sightings of 310, 23 sightings of 337, and 28 sightings of 389 long-finned pilot whales for the northern, central, and southern regions of Chile, respectively. Relative abundances were 3.9–4.4/day between 20.2°S and 32.2°S and 5.0/day between 32.2°S and 40°S from the SOWER sighting survey in December 1997–January 1998. From a winter sighting cruise (June–July 1995), Aguayo et al. (1998) reported a relative abundance for long-finned pilot whales of 1.5/day between 26.3°S and 33.1°S.

There are 10 records of long-finned pilot whales in the OBIS database for the central proposed survey area and 16 records for the southern proposed survey area; there are no records for the northern proposed survey area (OBIS 2015). There are no records of short-finned pilot whales in any of the proposed survey areas (OBIS 2015). Similarly, there are no records of either species in the SIBIMAP database for the proposed survey areas (CPPS 2015).

Burmeister’s porpoise (*Phocoena spinipinnis*)

Burmeister's porpoise occurs from ~5°S in northern Peru to ~40°S in Chile (Reyes 2009). It is a coastal, shallow water species limited to ~1000 m from shore and water depths < 25 m. In a study of drift gillnet and longline bycatch in northern Peru, Burmeister's porpoise constituted 6% of the recorded cetacean bycatch (Mangel et al. 2008).

Burmeister’s porpoise is common in northern Chile, where it has been hunted for human consumption and is incidentally caught in the gillnet fisheries (Aguayo-Lobo et al. 1998). Aguayo-Lobo et al. (1998) compiled 273 sightings of 353 in the northern region of Chile, many of which were in the northern proposed survey area, and 43 sightings of 71 for the central region of Chile, many of which were in the southern proposed survey area. The only relative abundance estimate reported was 5.0/day between 28°S and 37°S from a sighting survey in late spring/early summer (November–December) 1964 (Clarke et al. 1978 *in* Aguayo-Lobo et al. 1998).

The SIBIMAP database contains 4 records of this species for southern Chile, all inshore of Chiloé Island; there are no records for northern or central Chile (CPPS 2015). There are two records in the OBIS database for the southern proposed survey area, but none in the other two proposed survey areas (OBIS 2015).

Pinnipeds

Juan Fernández Fur Seal (*Arctocephalus philippii*)

The Juan Fernández fur seal is the only pinniped endemic to Chile (Osman et al. 2010). It was thought to be extirpated, but was rediscovered in 1965 (Reijnders et al. 1993). The Juan Fernández fur seal inhabits three islands in the Juan Fernández Archipelago (Robinson Crusoe, Santa Clara, and Alejandro Selkirk) and the two San Félix Islands (Osman 2008; Osman et al. 2010). The largest breeding colony in the Juan Fernández Archipelago is found at Lobería Vieja on Alejandro Selkirk Island (Osman 2008). An extensive census of the population during the December 2005–January 2006 breeding season provided a total population estimate of 32,278 (Osman 2008).

Juan Fernández fur seals travel long distances from their breeding colonies to foraging areas; foraging patterns are primarily influenced by prey distribution, which leads to extended foraging trips (Francis et al. 1998). Vagrants have been sighted along the Pacific coast of South America from southern

Peru to southern Chile (Reijnders et al. 1993; Jefferson et al. 2008); one individual traveled as far north as Colombia (Avila et al. 2014). Five females outfitted with a time-depth recorder traveled >500 km from their haul-out sites during foraging trips; although no individuals traveled north of 30°S, some traveled southeast towards mainland Chile, as far as 41°S, 76°W (Francis et al. 1998). Seven lactating females tagged with satellite transmitters traveled a mean distance of 1394 km (maximum 2921 km) during foraging trips in January and February lasting 11–41 days away from their pups (Osman 2008). Most foraging trips appeared to be associated with the productive waters of the Humboldt Current system, with most fur seals traveling south and southeast and one traveling to the coast near Concepcion Bay (~37°S), within the southern proposed survey area.

South American Fur Seal (*Arctocephalus australis*)

The South American fur seal occurs along the west and east coasts of South America; on the west coast, it is found from Peru to west of Tierra del Fuego (Arnould 2009). It has a discontinuous distribution, being absent along the coast of Chile from ~23°S to 43°S (Cárdenas-Alayza 2012), thus would not occur in the central or most of the southern proposed survey areas. It is thought to forage along the continental shelf and slope, but it may be seen as far as 600 km offshore (Jefferson et al. 2008). Its at-sea behavior is strongly influenced by bathymetry, sea state, and current direction (Dassis et al. 2012). Breeding occurs from mid October through mid December on rocky coasts (Jefferson et al. 2008). The breeding season in southern Chile occurs about one month later than elsewhere in South America (Pavés and Schlatter 2008). Small numbers of South American fur seals are hunted for human consumption in Peru and Chile (Jefferson et al. 2008), and their numbers in Peru have been severely depleted by El Niño events (Stevens and Boness 2003).

Sielfeld (1999) identified one breeding colony and 11 haul-out sites for South American fur seals in Chile Region I, which corresponds to the latitudinal range of the northern proposed survey area; he estimated that 750 fur seals use this region. Although there is only one breeding site in northern Chile, there are an additional 9 haul-out sites in Chile Region II, which extends south to ~26°S; Region II is used by ~850 fur seals. No breeding colonies or haul-out sites were reported for Regions III to IX (~26–41°S), the presence of colonies and haul-out sites was uncertain for Regions X and XI (~41–50°S), and the majority of fur seals occurred at breeding and haul out sites in Region XII, south of 50°S (Sielfeld 1999; Venegas et al. 2002). During 2012, Oliva et al. (2015) reported eight breeding colonies between 43.0°S and 48.4°S, including four main rookeries at Isla Guafo, Isla Paz, Caleta Dyer, and Isla Breaksea. The largest breeding colony, Isla Guafo, is located within the southern portion of the southern survey area. Five additional non-breeding haul-out sites were found during summer 2012, and another three haul-out sites were reported during winter 2011 (Oliva et al. 2015). During summer 2012, 8901 fur seals were counted; lower numbers in the region during winter suggest a southward migration to the Magallanes at that time (Oliva et al. 2015). SIO (2012) reported 70 sightings of *Arctocephalus* sp. in the northern portion of the southern proposed survey area.

South American Sea Lion (*Otaria flavescens*)

The South American sea lion is widely distributed along the South American coastline from Peru in the Pacific to southern Brazil in the Atlantic (Cappozzo and Perrin 2009). It is thought to feed primarily at night and return to land (at both breeding and haul-out sites) during the day (Sepúlveda et al. 2001, 2015a). It feeds in waters of the continental shelf, with foraging trips lasting a few days out to an average distance of ~200 km (Cappozzo and Perrin 2009). Sepúlveda et al. (2015b) reported that sea lions foraging off northern Chile, where the shelf is narrow, make shallower dives than those off southern Chile where the shelf is wider; sea lions in the northern region were shown to be epipelagic foragers whereas those in the south were feeding on pelagic and benthic fish. Sea lions that were tagged along the west coast of Chiloé Island did not move westward into offshore waters to forage, but rather entered the Gulf of Ancud.

Seasonal variations in abundance at both breeding and haul-out sites are related to the timing of breeding, with higher numbers at breeding sites during December–March with a peak in February, and lower numbers at haul-out sites (Sepúlveda et al. 2001, 2015a). Inter-annual variation in abundance at breeding sights in northern Chile is highly affected by El Niño events, with females taking longer foraging trips and having high rates of mortality and lower birth rates (Sepúlveda et al. 2015a).

Based on a 2007 census, there were 96 colonies (40 breeding colonies and 56 haul outs) of South American sea lions in northern Chile from 18°S to 32°S, with an estimated population size of 70,286; this region represents 54% of the total Chilean population of ~130,000 (Dans et al. 2012). Several of the colonies are located adjacent to the northern proposed survey area; tracked sea lions have been reported within the study area (Sepúlveda et al. 2015b). Contreras et al. (2014) reported counts from aerial survey censuses for winter 2012 and summer 2013; there were 27,009 in the winter and 37,681 in the summer at 14 different sites from Punta Pichalo (19.6°S) to Punta Lobos, Iquique (21.0°S). For central Chile, there were 33 colonies (6 breeding colonies and 27 haul outs) in Regions V to IX from 32°S to 39.4°S, with an estimated population size of 18,179 in 2007 (Dans et al. 2012). In Regions X and XI, from 39.4°S to 43.8°S, adjacent to the southern proposed survey area, there were 60 breeding colonies and 33 haul outs with an estimated population size of 46,682. SIO (2012) reported 4 sightings of 12 in the northern portion of the southern proposed survey area.

Southern elephant seal (*Mirounga leonina*)

The southern elephant seal has an extensive range, with breeding sites on islands throughout the sub-Antarctic (Hindell and Perrin 2009). Animals from the breeding colony on Península Valdés, Argentina, likely migrate up both coasts of South America (Lewis et al. 2006). When not on land to breed or molt, southern elephant seals use most of the Southern Ocean (Hindell and Perrin 2009). Breeding occurs from September to November, and molting takes place from December to March (Sepúlveda et al. 2007). The post-molt pelagic foraging phase lasts ~7 months. Individuals have been seen hauled out to molt as far north as Antofagasta (23.5°S) in January (Pacheco et al. 2011) and during November–January on Chañaral Island in the Humboldt Penguin National Reserve (Sepúlveda et al. 2007).

The proposed seismic survey is scheduled to occur while these animals would be foraging at sea post-molt. Although central Chile is considered part of the southern elephant seal's secondary range, northern Chile is not considered part of its range (Jefferson et al. 2008). However, extralimital records have been reported for northern Chile, Peru, and Ecuador (Lewis et al. 2006 *in* OBIS 2015). There are 6 records in the OBIS database for Chile north of 44°S, including 2 along the coast adjacent to the northern proposed survey area, 2 offshore from the central proposed survey area, 1 along the shore in between the northern and central proposed survey areas, and 1 along the shore in the southern proposed survey area; records for the northern and central proposed survey areas were from May through August, and the record from the southern proposed survey area was in February (Lewis et al. 2006 *in* OBIS 2015). Another 25 records exist farther south off Chile (Lewis et al. 2006 *in* OBIS 2015).

Lutrinids

Marine otter (*Lutra felina*)

The marine otter occurs along the west coast of South America from northern Peru to Cape Horn, but its distribution is fragmented based on the availability of suitable habitat (Valqui 2012b). The largest populations are thought to occur in Chilean waters (Jefferson et al. 2008), but no abundance estimates are available. Marine otters forage in the marine environment and use shelters in terrestrial habitats (Medina-Vogel et al. 2006). The feeding range of the marine otter extends inland by ~30 m and to ~150 m from shore (Castilla and Bahamondes 1979 and Ostfeld et al. 1989 *in* Medina-Vogel et al. 2006). Pups have been reported year-round in southern Chile, with a peak during September–November (Medina-Vogel et al. 2006).

The occurrence of the marine otter has been documented along the coast of Chile within the latitudinal range of all three proposed surveys (Valqui 2012b). Sielfeld and Castilla (1999) provided abundance estimates of 1.5/km of coastline for a 2-km section of the coastline in Chile Region I and 0.5–2.5/km for three different coastline surveys in Chile Region IV. Valqui (2012a) reported that numbers were 1.0–2.7/km, whereas Medina-Vogel et al. (2006) reported that numbers north of 29°S were 1.0–4.4/km. Medina-Vogel et al. (2006) reported 3.8/km in southern Chile, at ~39.7°S, from June 1999 to June 2000.

The marine otter would not be encountered during the proposed surveys as it occurs only in coastal waters, although it could be encountered during transit to and from port.

V. Type of Incidental Take Authorization Requested

The type of incidental taking authorization that is being requested (i.e., takes by harassment only, takes by harassment, injury and/or death), and the method of incidental taking.

L-DEO requests an IHA pursuant to Section 101 (a)(5)(D) of the MMPA for incidental take by harassment during its planned seismic surveys in the southeast Pacific Ocean in 2016/2017. An IHA covering an effective period of 1 year is requested, as the exact dates of the proposed surveys have not been determined at this time.

The operations outlined in § I have the potential to take marine mammals by harassment. Sounds would be generated by the airguns used during the survey, by echosounders, and by general vessel operations. "Takes" by harassment would potentially result when marine mammals near the activity are exposed to the pulsed sounds, such as those generated by the airguns. The effects would depend on the species of marine mammal, the behavior of the animal at the time of reception of the stimulus, as well as the distance and received level of the sound (see § VII). Disturbance reactions are likely amongst some of the marine mammals near the tracklines of the source vessel.

At most, effects on marine mammals would be anticipated as falling within the MMPA definition of "Level B Harassment" for those species managed by NMFS. No take by serious injury is expected, given the nature of the planned operations and the mitigation measures that are planned (see § XI, Mitigation Measures), and no lethal takes are expected. However, per NMFS requirement, L-DEO and NSF are also requesting small numbers of Level A takes for the remote possibility of low-level physiological effects. Because of the characteristics of the proposed study and the proposed monitoring and mitigation measures, in addition to the general avoidance by marine mammals of loud sounds, Level A takes are considered highly unlikely.

VI. NUMBERS OF MARINE MAMMALS THAT COULD BE TAKEN

By age, sex, and reproductive condition (if possible), the number of marine mammals (by species) that may be taken by each type of taking identified in [section V], and the number of times such takings by each type of taking are likely to occur.

The material for § VI and § VII has been combined and presented in reverse order to minimize duplication between sections.

VII. ANTICIPATED IMPACT ON SPECIES OR STOCKS

The anticipated impact of the activity upon the species or stock of marine mammal.

The material for § VI and § VII has been combined and presented in reverse order to minimize duplication between sections.

- First we summarize the potential impacts on marine mammals of airgun operations, as called for in § VII. A more comprehensive review of the relevant background information appears in § 3.6.4.3, § 3.7.4.3, § 3.8.4.3, and Appendix E of the PEIS.
- Then we summarize the potential impacts of operations by the echosounders. A more comprehensive review of the relevant background information appears in § 3.6.4.3, § 3.7.4.3, § 3.8.4.3, and Appendix E of the PEIS.
- Finally, we estimate the numbers of marine mammals that could be affected by the proposed surveys in the southeast Pacific Ocean. As called for in § VI, this section includes a description of the rationale for the estimates of the potential numbers of harassment "takes" during the planned surveys, as well Level A "takes", as required by NMFS. Acoustic modeling was conducted by L-DEO, determined to be acceptable by NMFS to use in the calculation of estimated takes under the MMPA (e.g., NMFS 2013a,b).

Summary of Potential Effects of Airgun Sounds

As noted in the PEIS (§ 3.6.4.3, § 3.7.4.3, and § 3.8.4.3), the effects of sounds from airguns could include one or more of the following: tolerance, masking of natural sounds, behavioral disturbance, and at least in theory, temporary or permanent hearing impairment, or non-auditory physical or physiological effects (Richardson et al. 1995; Gordon et al. 2004; Nowacek et al. 2007; Southall et al. 2007). In some cases, a behavioral response to a sound may in turn reduce the overall exposure to that sound (e.g., Finneran et al. 2015; Wensveen et al. 2015).

Permanent hearing impairment (PTS), in the unlikely event that it occurred, would constitute injury, but temporary threshold shift (TTS) is not considered an injury (Southall et al. 2007; Le Prell 2012). Rather, the onset of TTS has been considered an indicator that, if the animal is exposed to higher levels of that sound, physical damage is ultimately a possibility. Nonetheless, recent research has shown that sound exposure can cause cochlear neural degeneration, even when threshold shifts and hair cell damage are reversible (Liberman 2013). These findings have raised some doubts as to whether TTS should continue to be considered a non-injurious effect (Weilgart 2014; Tougaard et al. 2015). Although the possibility cannot be entirely excluded, it is unlikely that the proposed survey would result in any cases of temporary or permanent hearing impairment, or any significant non-auditory physical or physiological effects. If marine mammals encounter the survey while it is underway, some behavioral disturbance could result, but this would be localized and short-term.

Tolerance

Numerous studies have shown that pulsed sounds from airguns are often readily detectable in the water at distances of many kilometers (e.g., Nieukirk et al. 2012). Several studies have shown that marine mammals at distances more than a few kilometers from operating seismic vessels often show no apparent response. That is often true even in cases when the pulsed sounds must be readily audible to the animals based on measured received levels and the hearing sensitivity of that mammal group. Although various baleen and toothed whales, and (less frequently) pinnipeds have been shown to react behaviorally to airgun pulses under some conditions, at other times mammals of all three types have shown no overt reactions. The relative responsiveness of baleen and toothed whales are quite variable.

Masking

Masking effects of pulsed sounds (even from large arrays of airguns) on marine mammal calls and other natural sounds are expected to be limited, although there are very few specific data on this. Because of the intermittent nature and low duty cycle of seismic pulses, animals can emit and receive sounds in the relatively quiet intervals between pulses. However, in exceptional situations, reverberation occurs for much or all of the interval between pulses (e.g., Simard et al. 2005; Clark and Gagnon 2006), which could mask calls. Situations with prolonged strong reverberation are infrequent. However, it is common for reverberation to cause some lesser degree of elevation of the background level between airgun pulses (e.g., Gedamke 2011; Guerra et al. 2011, 2013; Klinck et al. 2012; Guan et al. 2015), and this weaker reverberation presumably reduces the detection range of calls and other natural sounds to some degree. Thus, airgun sounds could have masking effects and reduce the communication range especially of large whales (Nieukirk et al. 2012; Blackwell et al. 2013; Wittekind et al. 2013).

Some baleen and toothed whales are known to continue calling in the presence of seismic pulses, and their calls usually can be heard between the seismic pulses (e.g., Nieukirk et al. 2012; Broker et al. 2013). In addition, some cetaceans are known to change their calling rates, shift their peak frequencies, or otherwise modify their vocal behavior in response to airgun sounds (e.g., Di Iorio and Clark 2010; Castellote et al. 2012; Blackwell et al. 2013, 2015; Cerchio et al. 2014). The hearing systems of baleen whales are undoubtedly more sensitive to low-frequency sounds than are the ears of the small odontocetes that have been studied directly (e.g., MacGillivray et al. 2014). The sounds important to small odontocetes are predominantly at much higher frequencies than are the dominant components of airgun sounds, thus limiting the potential for masking. In general, masking effects of seismic pulses are expected to be minor, given the normally intermittent nature of seismic pulses.

Disturbance Reactions

Disturbance includes a variety of effects, including subtle to conspicuous changes in behavior, movement, and displacement. Based on NMFS (2001, p. 9293), NRC (2005), and Southall et al. (2007), we believe that simple exposure to sound, or brief reactions that do not disrupt behavioral patterns in a potentially significant manner, do not constitute harassment or "taking". By potentially significant, we mean, 'in a manner that might have deleterious effects to the well-being of individual marine mammals or their populations'.

Reactions to sound, if any, depend on species, state of maturity, experience, current activity, reproductive state, time of day, and many other factors (Richardson et al. 1995; Wartzok et al. 2004; Southall et al. 2007; Weilgart 2007; Ellison et al. 2012). If a marine mammal does react briefly to an underwater sound by changing its behavior or moving a small distance, the impacts of the change are unlikely to be significant to the individual, let alone the stock or population (New et al. 2013). However, if a sound source displaces marine mammals from an important feeding or breeding area for a prolonged period, impacts on individuals and populations could be significant (e.g., Lusseau and Bejder 2007; Weilgart 2007; Nowacek et al. 2015). Given the many uncertainties in predicting the quantity and types of impacts of noise on marine mammals, it is common practice to estimate how many marine mammals would be present within a particular distance of industrial activities and/or exposed to a particular level of industrial sound. In most cases, this approach likely overestimates the numbers of marine mammals that would be affected in some biologically important manner.

The sound criteria used to estimate how many marine mammals might be disturbed to some biologically important degree by a seismic program are based primarily on behavioral observations of a few species. Detailed studies have been done on humpback, gray, bowhead, and sperm whales. Less detailed data are available for some other species of baleen whales and small toothed whales, but for many species, there are no data on responses to marine seismic surveys.

Baleen Whales.—Baleen whales generally tend to avoid operating airguns, but avoidance radii are quite variable. Whales are often reported to show no overt reactions to pulses from large arrays of airguns at distances beyond a few kilometers, even though the airgun pulses remain well above ambient noise levels out to much longer distances. However, baleen whales exposed to strong noise pulses from airguns often react by deviating from their normal migration route and/or interrupting their feeding and moving away. In the cases of migrating gray and bowhead whales, the observed changes in behavior appeared to be of little or no biological consequence to the animals. They simply avoided the sound source by displacing their migration route to varying degrees, but within the natural boundaries of the migration corridors (Malme et al. 1984; Malme and Miles 1985; Richardson et al. 1995).

Responses of *humpback whales* to seismic surveys have been studied during migration, on summer feeding grounds, and on Angolan winter breeding grounds; there has also been discussion of effects on the Brazilian wintering grounds. Off Western Australia, avoidance reactions began at 5–8 km from the array, and those reactions kept most pods ~3–4 km from the operating seismic boat; there was localized displacement during migration of 4–5 km by traveling pods and 7–12 km by more sensitive resting pods of cow-calf pairs (McCauley et al. 1998, 2000). However, some individual humpback whales, especially males, approached within distances of 100–400 m.

In the northwest Atlantic, sighting rates were significantly greater during non-seismic periods compared with periods when a full array was operating, and humpback whales were more likely to swim away and less likely to swim towards a vessel during seismic vs. non-seismic periods (Moulton and Holst 2010). In contrast, sightings of humpback whales from seismic vessels off the U.K. from 1994 to 2010 indicated that detection rates were similar during seismic and non-seismic periods, although, sample sizes were small (Stone 2015). On their summer feeding grounds in southeast Alaska, there was no clear evidence of avoidance, despite the possibility of subtle effects, at received levels up to 172 re 1 μPa on an approximate rms basis (Malme et al. 1985). It has been suggested that South Atlantic humpback whales wintering off Brazil may be displaced or even strand upon exposure to seismic surveys (Engel et al. 2004), but data from subsequent years, indicated that there was no observable direct correlation between strandings and seismic surveys (IWC 2007).

There are no data on reactions of *right whales* to seismic surveys. However, Rolland et al. (2012) suggested that ship noise causes increased stress in right whales; they showed that baseline levels of stress-related faecal hormone metabolites decreased in North Atlantic right whales with a 6-dB decrease in underwater noise from vessels. Wright et al. (2011) and Atkinson et al. (2015) also reported that sound could be a potential source of stress for marine mammals.

Results from the closely related *bowhead whale* show that their responsiveness can be quite variable depending on their activity (migrating vs. feeding). Bowhead whales migrating west across the

Alaskan Beaufort Sea in autumn, in particular, are unusually responsive, with substantial avoidance occurring out to distances of 20–30 km from a medium-sized airgun source (Miller et al. 1999; Richardson et al. 1999). Subtle but statistically significant changes in surfacing–respiration–dive cycles were shown by traveling and socializing bowheads exposed to airgun sounds in the Beaufort Sea, including shorter surfacings, shorter dives, and decreased number of blows per surfacing (Robertson et al. 2013). More recent research on bowhead whales corroborates earlier evidence that, during the summer feeding season, bowheads are less responsive to seismic sources (e.g., Miller et al. 2005; Robertson et al. 2013).

Bowhead whale calls detected in the presence and absence of airgun sounds have been studied extensively in the Beaufort Sea. Bowheads continue to produce calls of the usual types when exposed to airgun sounds on their summering grounds, although numbers of calls detected are significantly lower in the presence than in the absence of airgun pulses (Blackwell et al. 2013, 2015). Blackwell et al. (2013) reported that calling rates in 2007 declined significantly where received SPLs from airgun sounds were 116–129 dB re 1 µPa; at SPLs <108 dB re 1 µPa, calling rates were not affected. When data for 2007–2010 were analyzed, Blackwell et al. (2015) reported an initial increase in calling rates when airgun pulses became detectable; however, calling rates leveled off at a received $CSEL_{10\text{-min}}$ (cumulative SEL over a 10-min period) of ~94 dB re 1 $\mu Pa^2 \cdot s$, decreased at $CSEL_{10\text{-min}}$ >127 dB re 1 $\mu Pa^2 \cdot s$, and whales were nearly silent at $CSEL_{10\text{-min}}$ >160 dB re 1 $\mu Pa^2 \cdot s$. Thus, bowhead whales in the Beaufort Sea apparently decreased their calling rates in response to seismic operations, although movement out of the area could also have contributed to the lower call detection rate (Blackwell et al. 2013, 2015).

A multivariate analysis of factors affecting the distribution of calling bowhead whales during their fall migration in 2009 noted that the southern edge of the distribution of calling whales was significantly closer to shore with increasing levels of airgun sound from a seismic survey a few hundred kilometers to the east of the study area (i.e., behind the westward-migrating whales; McDonald et al. 2010, 2011). It was not known whether this statistical effect represented a stronger tendency for quieting of the whales farther offshore in deeper water upon exposure to airgun sound, or an actual inshore displacement of whales.

Reactions of migrating and feeding (but not wintering) *gray whales* to seismic surveys have been studied. Off St. Lawrence Island in the northern Bering Sea, it was estimated, based on small sample sizes, that 50% of feeding gray whales stopped feeding at an average received pressure level of 173 dB re 1 µPa on an (approximate) rms basis, and that 10% of feeding whales interrupted feeding at received levels of 163 dB re 1 μPa_{rms} (Malme et al. 1986, 1988). Those findings were generally consistent with the results of experiments conducted on larger numbers of gray whales that were migrating along the California coast (Malme et al. 1984; Malme and Miles 1985) and western Pacific gray whales feeding off Sakhalin Island, Russia (e.g., Gailey et al. 2007; Johnson et al. 2007; Yazvenko et al. 2007a,b).

Various species of *Balaenoptera* (blue, sei, fin, and minke whales) have occasionally been seen in areas ensonified by airgun pulses. Sightings by observers on seismic vessels using large arrays off the U.K. from 1994 to 2010 showed that the detection rate for minke whales was significantly higher when airguns were not operating; however, during surveys with small arrays, the detection rates for minke whales were similar during seismic and non-seismic periods (Stone 2015). Sighting rates for fin and sei whales were similar when large arrays of airguns were operating vs. silent. All baleen whales combined tended to exhibit localized avoidance, remaining significantly farther (on average) from large arrays (median CPA ~1.5 km) during seismic operations compared with non-seismic periods (median CPA ~1.0 km). In addition, fin and minke whales were more often oriented away from the vessel while a large airgun array was active compared with periods of inactivity. Singing fin whales in the Mediterranean moved away from an operating airgun array, and their song notes had lower bandwidths during periods with vs. without airgun sounds (Castellote et al. 2012).

During seismic surveys in the northwest Atlantic, baleen whales as a group showed localized avoidance of the operating array (Moulton and Holst 2010). Sighting rates were significantly lower during seismic operations compared with non-seismic periods. Baleen whales were seen on average 200 m farther from the vessel during airgun activities vs. non-seismic periods, and these whales more often swam away from the vessel when seismic operations were underway compared with periods when no airguns were operating (Moulton and Holst 2010). Blue whales were seen significantly farther from the vessel during single airgun operations, ramp up, and all other airgun operations compared with non-seismic periods (Moulton and Holst 2010). Similarly, fin whales were seen at significantly farther distances during ramp up than during periods without airgun operations; there was also a trend for fin whales to be sighted farther from the vessel during other airgun operations, but the difference was not significant (Moulton and Holst 2010). Minke whales were seen significantly farther from the vessel during periods with than without seismic operations (Moulton and Holst 2010). Minke whales were also more likely to swim away and less likely to approach during seismic operations compared to periods when airguns were not operating (Moulton and Holst 2010).

Data on short-term reactions by cetaceans to impulsive noises are not necessarily indicative of long-term or biologically significant effects. It is not known whether impulsive sounds affect reproductive rate or distribution and habitat use in subsequent days or years. However, gray whales have continued to migrate annually along the west coast of North America with substantial increases in the population over recent years, despite intermittent seismic exploration (and much ship traffic) in that area for decades. The western Pacific gray whale population did not seem affected by a seismic survey in its feeding ground during a previous year, and bowhead whales have continued to travel to the eastern Beaufort Sea each summer, and their numbers have increased notably, despite seismic exploration in their summer and autumn range for many years.

Toothed Whales.—Little systematic information is available about reactions of toothed whales to sound pulses. However, there are recent systematic studies on sperm whales, and there is an increasing amount of information about responses of various odontocetes to seismic surveys based on monitoring studies. Seismic operators and marine mammal observers on seismic vessels regularly see dolphins and other small toothed whales near operating airgun arrays, but in general there is a tendency for most delphinids to show some avoidance of operating seismic vessels (e.g., Stone and Tasker 2006; Moulton and Holst 2010; Barry et al. 2012; Wole and Myade 2014; Stone 2015). In most cases, the avoidance radii for delphinids appear to be small, on the order of 1 km or less, and some individuals show no apparent avoidance.

Observations from seismic vessels using large arrays off the U.K. from 1994 to 2010 indicated that detection rates were significantly higher for killer whales, white-beaked dolphins, and Atlantic white-sided dolphins when airguns were not operating; detection rates during seismic vs. non-seismic periods were similar during seismic surveys using small arrays (Stone 2015). Detection rates for long-finned pilot whales, Risso's dolphins, bottlenose dolphins, and short-beaked common dolphins were similar during seismic (small or large array) vs. non-seismic operations. CPA distances for killer whales, white-beaked dolphins, and Atlantic white-sided dolphins were significantly farther (>0.5 km) from large airgun arrays during periods of airgun activity compared with periods of inactivity, with significantly more animals traveling away from the vessel during airgun operation. Observers' records suggested that fewer cetaceans were feeding and fewer delphinids were interacting with the survey vessel (e.g., bow-riding) during periods with airguns operating.

During seismic surveys in the northwest Atlantic, delphinids as a group showed some localized avoidance of the operating array (Moulton and Holst 2010). The mean initial detection distance was significantly farther (by ~200 m) during seismic operations compared with periods when the seismic source was not active; however, there was no significant difference between sighting rates (Moulton and Holst 2010). The same results were evident when only long-finned pilot whales were considered.

Preliminary findings of a monitoring study of narwhals in Melville Bay, Greenland (summer and fall 2012) showed no short-term effects of seismic survey activity on narwhal distribution, abundance, migration timing, and feeding habits (Heide-Jørgensen et al. 2013a). In addition, there were no reported effects on narwhal hunting. These findings do not seemingly support a suggestion by Heide-Jørgensen et al. (2013b) that seismic surveys in Baffin Bay may have delayed the migration timing of narwhals, thereby increasing the risk of narwhals to ice entrapment.

The beluga, however, is a species that (at least at times) shows long-distance (10s of km) avoidance of seismic vessels (e.g., Miller et al. 2005). Captive bottlenose dolphins and beluga whales exhibited changes in behavior when exposed to strong pulsed sounds similar in duration to those typically used in seismic surveys, but the animals tolerated high received levels of sound before exhibiting aversive behaviors (e.g., Finneran et al. 2000, 2002, 2005).

Most studies of sperm whales exposed to airgun sounds indicate that the sperm whale shows considerable tolerance of airgun pulses; in most cases the whales do not show strong avoidance (e.g., Stone and Tasker 2006; Moulton and Holst 2010), but foraging behavior can be altered upon exposure to airgun sound (e.g., Miller et al. 2009). Based on data collected by observers on seismic vessels off the U.K. from 1994 to 2010, detection rates for sperm whales were similar when large arrays of airguns were operating vs. silent; however, during surveys with small arrays, the detection rate was significantly higher when the airguns were not in operation (Stone 2015). Preliminary data from the Gulf of Mexico show reduced sperm whale acoustic activity during periods with airgun operations (Sidorovskaia et al. 2014).

There are almost no specific data on the behavioral reactions of beaked whales to seismic surveys. Most beaked whales tend to avoid approaching vessels of other types (e.g., Würsig et al. 1998) and/or change their behavior in response to sounds from vessels (e.g., Pirotta et al. 2012). Thus, it is likely that most beaked whales would also show strong avoidance of an approaching seismic vessel. Observations from seismic vessels off the U.K. from 1994 to 2010 indicated that detection rates of beaked whales were significantly higher ($p<0.05$) when airguns were not operating vs. when a large array was in operation, although sample sizes were small (Stone 2015). Some northern bottlenose whales remained in the general area and continued to produce high-frequency clicks when exposed to sound pulses from distant seismic surveys (e.g., Simard et al. 2005).

The limited available data suggest that harbor porpoises show stronger avoidance of seismic operations than do Dall's porpoises. Based on data collected by observers on seismic vessels off the U.K. from 1994 to 2010, detection rates of harbor porpoises were significantly higher when airguns were silent vs. when large or small arrays were operating; in addition, harbor porpoises were seen farther away from the array when it was operating vs. silent, and were most often seen traveling away from the airgun array when it was in operation (Stone 2015). Thompson et al. (2013) reported decreased densities and reduced acoustic detections of harbor porpoise in response to a seismic survey in Moray Firth, Scotland, at ranges of 5–10 km (SPLs of 165–172 dB re 1 μPa, SELs of 145–151 dB $\mu Pa^2 \cdot s$). For the same survey, Pirotta et al. (2014) reported that the probability of recording a porpoise buzz decreased by 15% in the ensonified area, and that the probability was positively related to the distance from the seismic ship; the decreased buzzing occurrence may indicate reduced foraging efficiency. Nonetheless, animals returned to the area within a few hours (Thompson et al. 2013). Kastelein et al. (2013a) reported that a harbor porpoise showed no response to an impulse sound with an SEL below 65 dB, but a 50% brief response rate was noted at an SEL of 92 dB and an SPL of 122 dB re 1 µPa$_{0\text{-peak}}$. The apparent tendency for greater responsiveness in the harbor porpoise is consistent with its relative responsiveness to boat traffic and some other acoustic sources (Richardson et al. 1995; Southall et al. 2007).

Odontocete reactions to large arrays of airguns are variable and, at least for delphinids, seem to be confined to a smaller radius than has been observed for the more responsive of the mysticetes and some other odontocetes. A ≥170 dB disturbance criterion (rather than ≥160 dB) is considered appropriate for delphinids, which tend to be less responsive than the more responsive cetaceans.

***Pinnipeds*.—**Pinnipeds are not likely to show a strong avoidance reaction to an airgun array. Visual monitoring from seismic vessels has shown only slight (if any) avoidance of airguns by pinnipeds and only slight (if any) changes in behavior. However, telemetry work has suggested that avoidance and other behavioral reactions may be stronger than evident to date from visual studies (Thompson et al. 1998). Observations from seismic vessels operating large arrays off the U.K. from 1994 to 2010 showed that the detection rate for grey seals was significantly higher when airguns were not operating; for surveys using small arrays, the detection rates were similar during seismic vs. non-seismic operations (Stone 2015). No significant differences in detection rates were apparent for harbor seals during seismic and non-seismic periods. There were no significant differences in CPA distances of grey or harbour seals during seismic vs. non-seismic periods. Lalas and McConnell (2015) made observations of New Zealand fur seals from a seismic vessel operating a 3090 in^3 airgun array in New Zealand during 2009. However, the results from the study were inconclusive in showing whether New Zealand fur seals respond to seismic sounds.

Hearing Impairment and Other Physical Effects

Temporary or permanent hearing impairment is a possibility when marine mammals are exposed to very strong sounds. TTS has been demonstrated and studied in certain captive odontocetes and pinnipeds exposed to strong sounds (reviewed by Southall et al. 2007; Finneran 2015). However, there has been no specific documentation of TTS let alone permanent hearing damage, i.e., PTS, in free-ranging marine mammals exposed to sequences of airgun pulses during realistic field conditions.

Additional data are needed to determine the received sound levels at which small odontocetes would start to incur TTS upon exposure to repeated, low-frequency pulses of airgun sound with variable received levels. To determine how close an airgun array would need to approach in order to elicit TTS, one would (as a minimum) need to allow for the sequence of distances at which airgun pulses would occur, and for the dependence of received SEL on distance in the region of the seismic operation (e.g., Breitzke and Bohlen 2010; Laws 2012). At the present state of knowledge, it is also necessary to assume that the effect is directly related to total received energy (SEL); however, this assumption is likely an over-simplification (Finneran 2012). There is recent evidence that auditory effects in a given animal are not a simple function of received acoustic energy (Finneran 2015). Frequency, duration of the exposure, and occurrence of gaps within the exposure can also influence the auditory effect (Finneran and Schlundt 2010, 2011, 2013; Finneran et al. 2010a,b; Popov et al. 2011, 2013a; Finneran 2012, 2015; Kastelein et al. 2012a,b; 2013b,c, 2014, 2015a; Ketten 2012).

Recent data have shown that the SEL required for TTS onset to occur increases with intermittent exposures, with some auditory recovery during silent periods between signals (Finneran et al. 2010b; Finneran and Schlundt 2011). Studies on bottlenose dolphins by Finneran et al. (2015) indicate that the potential for seismic surveys using airguns to cause auditory effects on dolphins could be lower than previously thought. Based on behavioral tests, Finneran et al. (2015) reported no measurable TTS in three bottlenose dolphins after exposure to 10 impulses from a seismic airgun with a cumulative SEL of up to ~195 dB re 1 µPa$^2 \cdot$s. However, auditory evoked potential measurements were more variable; one dolphin showed a small (9 dB) threshold shift at 8 kHz (Finneran et al. 2015).

Recent studies have also shown that the SEL necessary to elicit TTS can depend substantially on frequency, with susceptibility to TTS increasing with increasing frequency above 3 kHz (Finneran and Schlundt 2010, 2011; Finneran 2012). When beluga whales were exposed to fatiguing noise with sound levels of 165 dB re 1 µPa for durations of 1–30 min at frequencies of 11.2–90 kHz, the highest TTS with the longest recovery time was produced by the lower frequencies (11.2 and 22.5 kHz); TTS effects also gradually increased with prolonged exposure time (Popov et al. 2013a). Additionally, Popov et al. (2015) demonstrated that the impacts of TTS include deterioration of signal discrimination. Kastelein et al. (2015b) reported that exposure to multiple pulses with most energy at low frequencies can lead to TTS at higher frequencies in some cetaceans, such as the harbor porpoise.

Popov et al. (2013b) reported that TTS produced by exposure to a fatiguing noise was larger during the first session (or naïve subject state) with a beluga whale than TTS that resulted from the same sound in subsequent sessions (experienced subject state). Similarly, several other studies have shown that some marine mammals (e.g., bottlenose dolphins, false killer whales) can decrease their hearing sensitivity in order to mitigate the impacts of exposure to loud sounds (e.g., Nachtigall and Supin 2013, 2014, 2015)

Previous information on TTS for odontocetes was primarily derived from studies on the bottlenose dolphin and beluga, and that for pinnipeds has mostly been obtained from California sea lions and elephant seals (see § 3.6.4.3, § 3.7.4.3, § 3.8.4.3, and Appendix E of the PEIS). Thus, it is inappropriate to assume that onset of TTS occurs at similar received levels in all cetaceans or pinnipeds (cf. Southall et al. 2007). Some cetaceans or pinnipeds could incur TTS at lower sound exposures than are necessary to elicit TTS in the beluga and bottlenose dolphin or California sea lion and elephant seal, respectively.

Several studies on TTS in porpoises (e.g., Lucke et al. 2009; Popov et al. 2011; Kastelein et al. 2012a, 2013a,b, 2014, 2015a) indicate that received levels that elicit onset of TTS are lower in porpoises than in other odontocetes. Kastelein et al. (2012a) exposed a harbor porpoise to octave band noise centered at 4 kHz for extended periods. A 6-dB TTS occurred with SELs of 163 dB and 172 dB for low-intensity sound and medium-intensity sound, respectively; high-intensity sound caused a 9-dB TTS at a SEL of 175 dB (Kastelein et al. 2012a). Kastelein et al. (2013b) exposed a harbor porpoise to a long, continuous 1.5-kHz tone, which induced a 14-dB TTS with a total SEL of 190 dB. Popov et al. (2011) examined the effects of fatiguing noise on the hearing threshold of Yangtze finless porpoises when exposed to frequencies of 32–128 kHz at 140–160 dB re 1 µPa for 1–30 min. They found that an exposure of higher level and shorter duration produced a higher TTS than an exposure of equal SEL but of lower level and longer duration. Popov et al. (2011) reported a TTS of 25 dB for a Yangtze finless porpoise that was exposed to high levels of 3-min pulses of half-octave band noise centered at 45 kHz with an SEL of 163 dB.

Initial evidence from exposures to non-pulses has also suggested that some pinnipeds (harbor seals in particular) incur TTS at somewhat lower received levels than do most small odontocetes exposed for similar durations (Kastak et al. 1999, 2005, 2008; Ketten et al. 2001). Kastelein et al. (2012b) exposed two harbor seals to octave-band white noise centered at 4 kHz at three mean received SPLs of 124, 136, and 148 dB re 1 µPa; TTS >2.5 dB was induced at an SEL of 170 dB (136 dB SPL for 60 min), and the maximum TTS of 10 dB occurred after a 120-min exposure to 148 dB re 1 µPa or an SEL of 187 dB. Kastelein et al. (2013c) reported that a harbor seal unintentionally exposed to the same sound source with a mean received SPL of 163 dB re 1 µPa for 1 h induced a 44 dB TTS. For a harbor seal exposed to octave-band white noise centered at 4 kHz for 60 min with mean SPLs of 124–148 re 1 µPa, the onset of PTS would require a level of at least 22 dB above the TTS onset (Kastelein et al. 2013c).

Based on the best available information at the time, Southall et al. (2007) recommended a TTS threshold for exposure to single or multiple pulses of 183 dB re 1 $\mu Pa^2 \cdot s$ for all cetaceans and 173 dB re 1 $\mu Pa^2 \cdot s$ for pinnipeds in water. Tougaard et al. (2015) have suggested an exposure limit for TTS as an SEL of 100–110 dB above the porpoise pure tone hearing threshold at a specific frequency; they also suggested an exposure limit of Leq-fast (rms average over the duration of the pulse) of 45 dB above the hearing threshold for behavioral responses (i.e., negative phonotaxis). In addition, M-weighting, as used by Southall et al. (2007), might not be appropriate for the harbor porpoise (Wensveen et al. 2014; Tougaard et al. 2015); thus, Wensveen et al. (2014) developed six auditory weighting functions for the harbor porpoise that could be useful in predicting TTS onset. Gedamke et al. (2011), based on preliminary simulation modeling that attempted to allow for various uncertainties in assumptions and variability around population means, suggested that some baleen whales whose closest point of approach to a seismic vessel is 1 km or more could experience TTS.

Hermannsen et al. (2015) reported that there is little risk of hearing damage to harbor seals or harbor porpoises when using single airguns in shallow water. Similarly, it is unlikely that a marine mammal would remain close enough to a large airgun array for sufficiently long to incur TTS, let alone PTS. There is no specific evidence that exposure to pulses of airgun sound can cause PTS in any marine mammal, even with large arrays of airguns. However, given the possibility that some mammals close to an airgun array might incur at least mild TTS, there has been further speculation about the possibility that some individuals occurring very close to airguns might incur PTS (e.g., Richardson et al. 1995, p. 372ff; Gedamke et al. 2011). In terrestrial animals, exposure to sounds sufficiently strong to elicit a large TTS induces physiological and structural changes in the inner ear, and at some high level of sound exposure, these phenomena become non-recoverable (Le Prell 2012). At this level of sound exposure, TTS grades into PTS. Single or occasional occurrences of mild TTS are not indicative of permanent auditory damage, but repeated or (in some cases) single exposures to a level well above that causing TTS onset might elicit PTS (e.g., Kastak and Reichmuth 2007; Kastak et al. 2008).

Current NMFS policy regarding exposure of marine mammals to high-level sounds is that cetaceans and pinnipeds should not be exposed to impulsive sounds with received levels ≥180 dB and 190 dB re 1 μPa_{rms}, respectively (NMFS 2000). These criteria have been used in establishing the exclusion (=shut-down) zones planned for the proposed seismic survey. However, those criteria were established before there was any information about minimum received levels of sounds necessary to cause auditory impairment in marine mammals.

Recommendations for science-based noise exposure criteria for marine mammals, frequency-weighting procedures, and related matters were published by Southall et al. (2007). Those recommendations were never formally adopted by NMFS for use in regulatory processes and during mitigation programs associated with seismic surveys, although some aspects of the recommendations have been taken into account in certain environmental impact statements and small-take authorizations. In July 2015, NOAA made available for a second public comment period new draft guidance for assessing the effects of anthropogenic sound on marine mammals (NOAA 2015), taking at least some of the Southall et al. recommendations into account, as well as more recent literature. At the time of preparation of this request, the content of the final guidelines and how they would be implemented are uncertain.

Nowacek et al. (2013) concluded that current scientific data indicate that seismic airguns have a low probability of directly harming marine life, except at close range. Several aspects of the planned monitoring and mitigation measures for this project are designed to detect marine mammals occurring near the airgun array, and to avoid exposing them to sound pulses that might, at least in theory, cause hearing impairment (see § XI and § XIII). Also, many marine mammals and (to a limited degree) sea turtles show some avoidance of the area where received levels of airgun sound are high enough such that hearing impairment could potentially occur. In those cases, the avoidance responses of the animals themselves would reduce or (most likely) avoid any possibility of hearing impairment.

Non-auditory physical effects may also occur in marine mammals exposed to strong underwater pulsed sound. Possible types of non-auditory physiological effects or injuries that might (in theory) occur in mammals close to a strong sound source include stress, neurological effects, bubble formation, and other types of organ or tissue damage. It is possible that some marine mammal species (i.e., beaked whales) are especially susceptible to injury and/or stranding when exposed to strong transient sounds.

There is no definitive evidence that any of these effects occur even for marine mammals in close proximity to large arrays of airguns. However, Gray and Van Waerebeek (2011) have suggested a cause-effect relationship between a seismic survey off Liberia in 2009 and the erratic movement, postural instability, and akinesia in a pantropical spotted dolphin based on spatially and temporally close association with the airgun array. Additionally, a few cases of strandings in the general area where a seismic survey was ongoing have led to speculation concerning a possible link between seismic surveys and strandings (e.g., Castellote and Llorens 2013).

Non-auditory effects, if they occur at all, would presumably be limited to short distances and to activities that extend over a prolonged period. Marine mammals that show behavioral avoidance of seismic vessels, including most baleen whales, some odontocetes, and some pinnipeds, are especially unlikely to incur non-auditory physical effects. The brief duration of exposure of any given mammal and the planned monitoring and mitigation measures would further reduce the probability of exposure of marine mammals to sounds strong enough to induce non-auditory physical effects.

Possible Effects of Other Acoustic Sources

The Kongsberg EM 122 MBES and Knudsen Chirp 3260 SBP would be operated from the source vessel during the proposed survey. Information about this equipment was provided in § 2.2.3.1 of the PEIS. A review of the expected potential effects (or lack thereof) of MBESs, SBPs, and pingers on marine mammals appears in § 3.6.4.3, § 3.7.4.3, and § 3.8.4.3 and Appendix E of the PEIS.

There has been some recent attention given to the effects of MBES on marine mammals, as a result of a report issued in September 2013 by an IWC independent scientific review panel linking the operation of an MBES to a mass stranding of melon-headed whales (*Peponocephala electra*; Southall et al. 2013) off Madagascar. During May–June 2008, ~100 melon-headed whales entered and stranded in the Loza Lagoon system in northwest Madagascar at the same time that a 12-kHz MBES survey was being conducted ~65 km away off the coast. In conducting a retrospective review of available information on the event, an independent scientific review panel concluded that the Kongsberg EM 120 MBES was the most plausible behavioral trigger for the animals initially entering the lagoon system and eventually stranding. The independent scientific review panel, however, identified that an unequivocal conclusion on causality of the event was not possible because of the lack of information about the event and a number of potentially contributing factors. Additionally, the independent review panel report indicated that this incident was likely the result of a complicated confluence of environmental, social, and other factors that have a very low probability of occurring again in the future, but recommended that the potential be considered in environmental planning. It should be noted that this event is the first known marine mammal mass stranding closely associated with the operation of an MBES. Leading scientific experts knowledgeable about MBES have expressed concerns about the independent scientific review panel analyses and findings (Bernstein 2013).

Lurton (2015) modeled MBES radiation characteristics (pulse design, source level, and radiation directivity pattern) applied to a low-frequency (12-kHz), 240-dB source-level system like that used on the *Langseth*. Using Southall et al. (2007) thresholds, he found that injury impacts were possible only at very short distances, e.g., at 5 m for maximum SPL and 12 m for cumulative SEL for cetaceans; corresponding distances for behavioural response were 9 m and 70 m. For pinnipeds, "all ranges are multiplied by a factor of 4" (Lurton 2015:209).

There is no available information on marine mammal behavioral response to MBES sounds (Southall et al. 2013). Much of the literature on marine mammal response to sonars relates to the types of sonars used in naval operations, including Low-Frequency Active (LFA) sonars (e.g., Miller et al. 2012; Sivle et al. 2012) and Mid-Frequency Active (MFA) sonars (e.g., Tyack et al. 2011; Melcón et al. 2012; Miller et al. 2012; DeRuiter et al. 2013a,b; Goldbogen et al. 2013; Baird et al. 2014; Wensveen et al. 2015). However, the MBES sounds are quite different from naval sonars. Ping duration of the MBES is very short relative to naval sonars. Also, at any given location, an individual marine mammal would be in the beam of the MBES for much less time given the generally downward orientation of the beam and its narrow fore-aft beamwidth; naval sonars often use near-horizontally-directed sound. In addition, naval sonars have higher duty cycles. These factors would all reduce the sound energy received from the MBES relative to that from naval sonars.

In the fall of 2006, an Ocean Acoustic Waveguide Remote Sensing (OAWRS) experiment was carried out in the Gulf of Maine (Gong et al. 2014); the OAWRS emitted three frequency-modulated (FM) pulses centered at frequencies of 415, 734, and 949 Hz (Risch et al. 2012). Risch et al. (2012) found a reduction in humpback whale song in the Stellwagen Bank National Marine Sanctuary during OAWRS activities that were carried out ~200 km away; received levels in the sanctuary were 88–110 dB re 1 µPa. In contrast, Gong et al. (2014) reported no effect of the OAWRS signals on humpback whale vocalizations in the Gulf of Maine. Range to the source, ambient noise, and/or behavioral state may have differentially influenced the behavioral responses of humpbacks in the two areas (Risch et al. 2014).

Deng et al (2014) measured the spectral properties of pulses transmitted by three 200-kHz echosounders, and found that they generated weaker sounds at frequencies below the center frequency (90–130 kHz). These sounds are within the hearing range of some marine mammals, and the authors suggested that they could be strong enough to elicit behavioral responses within close proximity to the sources, although they would be well below potentially harmful levels. Hastie et al. (2014) reported behavioral responses by grey seals to echosounders with frequencies of 200 and 375 kHz.

Despite the aforementioned information that has recently become available, and in agreement with § 3.6.7, 3.7.7, and 3.8.7 of the PEIS, the operation of MBESs, SBPs, and pingers is not likely to impact marine mammals, (1) given the lower acoustic exposures relative to airguns and (2) because the intermittent and/or narrow downward-directed nature of these sounds would result in no more than one or two brief ping exposures of any individual marine mammal given the movement and speed of the vessel.

Other Possible Effects of Seismic Surveys

Other possible effects of seismic surveys on marine mammals include masking by vessel noise, disturbance by vessel presence or noise, and injury or mortality from collisions with vessels or entanglement in seismic gear.

Vessel noise from the *Langseth* could affect marine animals in the proposed survey areas. Sounds produced by large vessels generally dominate ambient noise at frequencies from 20 to 300 Hz

(Richardson et al. 1995). However, some energy is also produced at higher frequencies (Hermannsen et al. 2014); low levels of high-frequency sound from vessels has been shown to elicit responses in harbor porpoise (Dyndo et al. 2015). Ship noise, through masking, can reduce the effective communication distance of a marine mammal if the frequency of the sound source is close to that used by the animal, and if the sound is present for a significant fraction of time (e.g., Richardson et al. 1995; Clark et al. 2009; Jensen et al. 2009; Gervaise et al. 2012; Hatch et al. 2012; Rice et al. 2014). In addition to the frequency and duration of the masking sound, the strength, temporal pattern, and location of the introduced sound also play a role in the extent of the masking (Branstetter et al. 2013; Finneran and Branstetter 2013). Branstetter et al. (2013) reported that time-domain metrics are also important in describing and predicting masking. In order to compensate for increased ambient noise, some cetaceans are known to increase the source levels of their calls in the presence of elevated noise levels from shipping, shift their peak frequencies, or otherwise change their vocal behavior (e.g., Parks et al. 2011; 2012; Castellote et al. 2012; Melcón et al. 2012; Tyack and Janik 2013; Luís et al. 2014; Sairanen 2014; Papale et al. 2015). Holt et al. (2015) reported that changes in vocal modifications can have increased energetic costs for individual marine mammals.

Baleen whales are thought to be more sensitive to sound at these low frequencies than are toothed whales (e.g., MacGillivray et al. 2014), possibly causing localized avoidance of the proposed survey areas during seismic operations. Reactions of gray and humpback whales to vessels have been studied, and there is limited information available about the reactions of right whales and rorquals (fin, blue, and minke whales). Reactions of humpback whales to boats are variable, ranging from approach to avoidance (Payne 1978; Salden 1993). Baker et al. (1982, 1983) and Baker and Herman (1989) found humpbacks often move away when vessels are within several kilometers. Humpbacks seem less likely to react overtly when actively feeding than when resting or engaged in other activities (Krieger and Wing 1984, 1986).

Many odontocetes show considerable tolerance of vessel traffic, although they sometimes react at long distances if confined by ice or shallow water, if previously harassed by vessels, or have had little or no recent exposure to ships (Richardson et al. 1995). Dolphins of many species tolerate and sometimes approach vessels. Some dolphin species approach moving vessels to ride the bow or stern waves (Williams et al. 1992). Pirotta et al. (2015) noted that the physical presence of vessels, not just ship noise, disturbed the foraging activity of bottlenose dolphins. There are few data on the behavioral reactions of beaked whales to vessel noise, though they seem to avoid approaching vessels (e.g., Würsig et al. 1998) or dive for an extended period when approached by a vessel (e.g., Kasuya 1986). Based on a single observation, Aguilar Soto et al. (2006) suggest foraging efficiency of Cuvier's beaked whales may be reduced by close approach of vessels.

The PEIS concluded that project vessel sounds would not be at levels expected to cause anything more than possible localized and temporary behavioral changes in marine mammals, and would not be expected to result in significant negative effects on individuals or at the population level. In addition, in all oceans of the world, large vessel traffic is currently so prevalent that it is commonly considered a usual source of ambient sound.

Another concern with vessel traffic is the potential for striking marine mammals. Information on vessel strikes is reviewed in § 3.6.4.4 and § 3.8.4.4 of the PEIS. The PEIS concluded that the risk of collision of seismic vessels or towed/deployed equipment with marine mammals exists but is extremely unlikely, because of the relatively slow operating speed (typically 7–9 km/h) of the vessel during seismic operations, and the generally straight-line movement of the seismic vessel. There has been no history of marine mammal vessel strikes with the R/V *Langseth,* or its predecessor, R/V *Maurice Ewing* over the last two decades.

Numbers of Marine Mammals that could be "Taken by Harassment"

All anticipated takes would be "takes by harassment", involving temporary changes in behavior. The mitigation measures to be applied would minimize the possibility of injurious takes. (However, as noted earlier, there is no specific information demonstrating that injurious "takes" would occur even in the absence of the planned mitigation measures.) In the sections below, we describe methods to estimate the number of potential exposures to various received sound levels and present estimates of the numbers of marine mammals that could be affected during the proposed seismic program. The estimates are based on consideration of the number of marine mammals that could be disturbed appreciably by the seismic surveys off the coast of Chile in non-Territorial Waters. The main sources of distributional and numerical data used in deriving the estimates are described in the next subsection.

It is assumed that, during simultaneous operations of the airgun array and the other sources, any marine mammals close enough to be affected by the MBES and SBP would already be affected by the airguns. However, whether or not the airguns are operating simultaneously with the other sources, marine mammals are expected to exhibit no more than short-term and inconsequential responses to the MBES and SBP, given their characteristics (e.g., narrow downward-directed beam) and other considerations described in § 3.6.4.3, § 3.7.4.3, § 3.8.4.3, and Appendix E of the PEIS. Such reactions are not considered to constitute "taking" (NMFS 2001). Therefore, no additional allowance is included for animals that could be affected by sound sources other than airguns.

Basis for Estimating "Takes"

The estimates are based on a consideration of the number of marine mammals that could be within the area around the operating airgun array where received levels of sound ≥160 dB re 1 μPa_{rms} are predicted to occur (see Table 1). The estimated numbers are based on the densities (numbers per unit area) of marine mammals expected to occur in the area in the absence of a seismic survey. To the extent that marine mammals tend to move away from seismic sources before the sound level reaches the criterion level and tend not to approach an operating airgun array, these estimates likely overestimate the numbers actually exposed to the specified level of sound. The overestimation is expected to be particularly large when dealing with the higher sound level criteria, e.g., 180 dB re 1 μPa_{rms}, as animals are more likely to move away when received levels are higher. Likewise, they are less likely to approach within the ≥180 or 190 dB re 1 μPa_{rms} radii than they are to approach within the considerably larger ≥160 dB radius.

To our knowledge, no systematic aircraft- or ship-based surveys have been conducted for marine mammals in waters of the southeast Pacific Ocean off the coast of Chile. Similar to methodology used for the 2012 survey off Chile by SIO, for most cetacean species, we used densities from extensive NMFS SWFSC cruises (Ferguson and Barlow 2001, 2003; Barlow 2003, 2010; Forney 2007) in one province of Longhurst's (2006) pelagic biogeography, the California Current Province (CALC). That province is similar to the Humboldt Current Coastal Province (HUMB) in which the proposed surveys are located; both are eastern boundary currents in this Pacific Coastal Biome that feature narrow continental shelves, upwelling, high productivity, and fluctuating fishery resources (sardines and anchovies). Specifically, we used the 1986–1996 data from Ferguson and Barlow's (2001, 2003) 5º×5º blocks whose latitudes and distances from shore are analogous to those of the proposed survey areas (71, 72, 85, 86, 102, and 103 for the northern proposed survey; 58, 59, 71, 72, 85, and 86 for the central proposed survey; and 34, 35, 36, 46, 47, 48, 58, and 59 for the southern proposed survey), and the 2001 data from Barlow's (2003) California (CA) stratum and the 2005 and 2008 data, respectively, from Forney's (2007) and Barlow's (2010) southern CA strata for all three proposed survey areas. The densities used were survey effort-weighted means for the locations (blocks or States). The 2001, 2005, and 2008 surveys off CA were conducted up to ~556 km offshore in areas that overlap with the blocks selected from Ferguson and Barlow (2001, 2003).

Densities used here were either taken directly from the reports (Ferguson and Barlow 2001, 2003; Barlow 2003; Forney 2007), or were calculated using standard line-transect methods (Buckland et al. 2001) from sightings, mean group size, and survey effort data from the report (Barlow 2010). The survey efforts used to weight mean densities from the surveys were from the survey reports except for the 2005 data for southern CA, where the survey effort was estimated based on measurements of tracklines in Figure 1 of Forney (2007). All reported densities have been corrected for both detectability and availability bias by the authors or for the calculated densities from Barlow (2010), using data therein. Detectability bias [$f(0)$] is associated with diminishing sightability with increasing lateral distance from the trackline; availability bias [$g(0)$] refers to the fact that there is <100% probability of sighting an animal that is present along the survey trackline. Densities reported for unidentified sightings (e.g., *Kogia* sp., rorquals, large whales) were allocated to appropriate species in proportion to the calculated densities of those species in the areas selected. Calculated densities are shown in Tables 3–5.

Using the aforementioned methods yielded density estimates of 0.54, 2.10, and 2.07/km^2 for blue whales in the northern, central, and southern proposed survey areas, respectively. Since a feeding aggregation area for this species occurs between 39°S and 44°S during February–April, we used data from surveys off southern Chile (up to 40 km from shore) by Galletti Vernazzani et al. (2012) to estimate density for the southern proposed survey area for austral summer/fall. Density was calculated using standard line-transect methods (Buckland et al. 2001) from sightings, mean group size, and survey effort data for sub-areas A-D collected during aerial surveys conducted off southern Chile between 2004 and 2010 (Galletti Vernazzani et al. 2012). The density was corrected for both detectability and availability bias using data from Barlow (2010). Given that aggregations of blue whales are expected to occur only in half of the southern proposed survey area (south of 39°S), and that the proposed survey area extends farther offshore (>100 km) than surveys by Galletti Vernazzani et al. (2012), we corrected the calculated density (9.56/km^2) by reducing it by 50%, which resulted in an estimate of 4.78/km^2 for austral summer/fall (Table 5). The density for austral winter/spring is expected to be lower (~2.07/km^2).

We have used densities for some Northern Hemisphere species that are similar to Southern Hemisphere species that occur in the proposed survey areas: we used northern right whale dolphin for southern right whale dolphin, Pacific white-sided dolphin for dusky dolphin (both are *Lagenorhynchus* species, occupy shelf waters, usually have group sizes 10–100, and feed primarily on small, schooling fish), and Dall's porpoise for Burmeister's porpoise (both are *Phocoena* species, primarily coastal, usually alone or in small groups, and feed primarily on small, schooling fish). Densities for short-finned pilot whales were used for long-finned pilot whales, as the latter are much more abundant off Chile (see § 3.3.2.26). In the case of Peale's and Chilean dolphins, we used the same density as for Risso's dolphin, because all three delphinid species are predicted to be uncommon in the central and southern proposed survey areas (see Table 2).

The at-sea density estimate for South American sea lions was calculated during an ~1800-km repeated trackline survey off the Chilean northern Patagonia coast (41.5–45.5°S) by Bedriñana-Romano et al. (2014). The densities have been corrected for detectability bias by the authors and assumed an availability bias of 1. The at-sea density estimate for South American fur seals for northern and southern Chile was also based on the South American sea lion density reported by Bedriñana-Romano et al.

TABLE 3. Densities and estimates of the possible numbers of individuals that could be exposed to ≥160 and 180 or 190 dB re 1 μPa$_{rms}$ during the northern proposed seismic survey off Chile in the south-east Pacific Ocean in 2016/2017. The proposed sound source consists of a 36-airgun array with a total discharge volume of ~6600 in^3. Species in italics are listed under the ESA as endangered. The column of numbers in boldface shows the numbers of Level A and B "takes" for which authorization is requested.

Species	Estimated Density[1] (#/1000 km^2)	Calculated Take, NMFS Daily Method[2] Level A[3]	Calculated Take, NMFS Daily Method[2] Level B[4]	Requested Take as % of Pop.[5]	Requested Level A + B Take Authorization[6]
Mysticetes					
Southern right whale	*0*	*0*	0	*0.10*	***12[7]***
Humpback whale	*0.32*	*4*	23	*0.10*	***42[7]***
Common (dwarf) minke whale	0.34	4	25	0.01	**29**
Antarctic minke whale	0	0	0	<0.01	**2[8]**
Bryde's whale	0.47	6	34	0.38	**40**
Sei whale	*0*	*0*	0	*0.10*	***10[7]***
Fin whale	*1.40*	*19*	100	*0.79*	***119***
Blue whale	*0.54*	*7*	38	*1.20*	***45***
Odontocetes					
Sperm whale	*1.19*	*16*	85	*2.44*	***101***
Dwarf sperm whale	8.92	118	639	6.76	**757**
Pygmy sperm whale	2.73	36	196	N.A.	**232**
Cuvier's beaked whale	2.36	31	169	1.00	**200**
Pygmy beaked whale	0.70	9	50	0.23	**59**
Mesoplodont spp.[9]	1.95	26	139	0.65	**165**
Rough-toothed dolphin	7.05	94	505	0.56	**599**
Common bottlenose dolphin	18.4	245	1321	0.47	**1566**
Striped dolphin	61.4	815	4395	0.54	**5210**
Short-beaked common dolphin	356.3	4731	25,522	1.71	**30,253**
Long-beaked common dolphin	50.3	667	3600	N.A.	**4267**
Dusky dolphin	13.7	182	985	N.A.	**1167**
Southern right whale dolphin	3.34	44	239	N.A.	**283**
Risso's dolphin	29.8	396	2137	2.29	**2533**
Pygmy killer whale	1.31	17	95	0.29	**112**
False killer whale	0.63	8	45	0.13	**53**
Killer whale	0.23	3	17	0.23	**20**
Short-finned pilot whale	0	0	0	0.01	**18[8]**
Long-finned pilot whale	1.09	14	78	0.02	**92**
Burmeister's porpoise	5.15	68	369	N.A.	**437**
Pinnipeds					
Juan Fernandez fur seal	0	0	0	0.01	**3[8]**
South American fur seal	37.9	156	3061	13.08	**3217**
South American sea lion	393.0	1621	31,750	13.08	**33,371**

[1] No correction factors were applied to these calculations; see text for density sources.
[2] Take using NMFS daily method for calculating ensonified area: estimated density multiplied by the daily ensonified area on one selected day (see text) multiplied by the number of survey days (28) times 1.25; daily ensonified areas used to calculate Level B takes = full 160-dB (2426.1 km^2) area minus the 180-dB (379.4 km^2) or 190-dB (117.8 km^2) areas.
[3] Level A takes if there were no mitigation measures, based on the 180- and 190-dB criteria for cetaceans and pinnipeds, respectively.
[4] Level B takes, based on the 160-dB criterion, excluding exposures to sound levels ≥180 dB (Level A takes).
[5] Requested Level A and B takes (used by NMFS as proxy for number of individuals exposed) expressed as % of population; N.A. = population size not available (see Table 2).
[6] Requested take authorization is Level A plus Level B calculated takes, unless otherwise indicated.
[7] Requested take authorization increased to 0.1% for ESA-listed species; increases made to Level B takes only.
[8] Requested take authorization (Level B only) increased to mean group size for non-listed species (see text for sources).
[9] May include Gray's and/or Blainville's beaked whales.

TABLE 4. Densities and estimates of the possible numbers of individuals that could be exposed to ≥160 and 180 or 190 dB re 1 µPa$_{rms}$ during the central proposed seismic survey off Chile in the southeast Pacific Ocean during 2016/2017. The proposed sound source consists of a 36-airgun array with a total discharge volume of ~6600 in^3. Species in italics are listed under the ESA as endangered. The column of numbers in boldface shows the numbers of Level A and B "takes" for which authorization is requested.

Species	Estimated Density[1] (#/1000 km^2)	Calculated Take, NMFS Daily Method[2]		Requested Take as % of Pop.[5]	Requested Level A + B Take Authorization[6]
		Level A[3]	Level B[4]		
Mysticetes					
Southern right whale	*0*	*0*	0	*0.10*	***12[7]***
Pygmy right whale	0	0	0	N.A.	**1[8]**
Humpback whale	*0.43*	*1*	4	*0.10*	***42[7]***
Common (dwarf) minke whale	0.34	1	3	<0.01	**4**
Antarctic minke whale	0	0	0	<0.01	**2[8]**
Bryde's whale	0.41	1	4	0.05	**5**
Sei whale	*0*	*0*	0	*0.10*	***10[7]***
Fin whale	*1.96*	*4*	20	*0.16*	***24***
Blue whale	*2.10*	*4*	22	*0.67*	***26***
Odontocetes					
Sperm whale	*1.22*	*2*	13	*0.36*	***15***
Dwarf sperm whale	7.98	15	82	0.87	**97**
Pygmy sperm whale	2.98	6	30	N.A.	**36**
Cuvier's beaked whale	3.02	6	31	0.18	**37**
Shepherd's beaked whale	0	0	0	N.A.	**10[8]**
Southern bottlenose whale	0	0	0	0.01	**4[8]**
Pygmy beaked whale	0.55	1	6	0.03	**7**
Mesoplodont spp.[9]	1.54	3	16	0.07	**19**
Chilean dolphin	21.2	40	219	N.A.	**259**
Common bottlenose dolphin	12.3	23	128	0.04	**151**
Striped dolphin	46.7	87	483	0.06	**570**
Short-beaked common dolphin	503.5	942	5207	0.35	**6149**
Dusky dolphin	14.8	28	153	N.A.	**181**
Peale's dolphin	21.2	40	219	N.A.	**259**
Hourglass dolphin	0	0	0	<0.01	**5[8]**
Southern right whale dolphin	6.07	11	63	N.A.	**74**
Risso's dolphin	21.2	40	219	0.23	**259**
Pygmy killer whale	0	0	0	0.07	**28[8]**
False killer whale	0.54	1	6	0.03	**11[8]**
Killer whale	0.28	1	2	0.06	**5[8]**
Short-finned pilot whale	0	0	0	0.01	**18[8]**
Long-finned pilot whale	0.94	2	9	<0.01	**18[8]**
Burmeister's porpoise	4.92	9	51	N.A.	**60**
Pinnipeds					
Juan Fernandez fur seal	0	0	0	0.01	**3[8]**
South American fur seal	37.9	22	441	1.88	**463**
South American sea lion	393.0	225	4575	1.88	**4800**
Southern elephant seal	0	0	0	<0.01	**2[8]**

[1] No correction factors were applied to these calculations; see text for density sources. N.A. = not available.
[2] Take using NMFS daily method for calculating ensonified area: estimated density multiplied by the daily ensonified area on one selected day (see text) multiplied by the number of survey days (5) times 1.25; daily ensonified areas used to calculate Level B takes = full 160-dB (1954.0 km^2) area minus the 180-dB (299.3 km^2) or 190-dB (91.8 km^2) areas.
[3] Level A takes if there were no mitigation measures, based on the 180- and 190-dB criteria for cetaceans and pinnipeds, respectively.
[4] Level B takes, based on the 160-dB criterion, excluding exposures to sound levels ≥180 dB (Level A takes).
[5] Requested Level A and B takes (used by NMFS as proxy for number of individuals exposed) expressed as % of population.
[6] Requested take authorization is Level A plus Level B calculated takes, unless otherwise indicated.
[7] Requested take authorization increased to 0.1% for ESA-listed species; increases made to Level B takes only.
[8] Requested take authorization (Level B only) increased to mean group size for non-listed species (see text for sources).
[9] May include Hector's, Gray's, Andrew's, Blainville's, strap-toothed, and/or spade-toothed beaked whales.

TABLE 5. Densities and estimates of the possible numbers of individuals that could be exposed to ≥160 and 180 or 190 dB re 1 µPa$_{rms}$ during the southern proposed seismic survey off Chile in the southeast Pacific Ocean in 2016/2017. The proposed sound source consists of a 36-airgun array with a total discharge volume of ~6600 in^3. Species in italics are listed under the ESA as endangered. The column of numbers in boldface shows the numbers of Level A and B "takes" for which authorization is requested.

Species	Estimated Density[1] (#/1000 km^2)	Calculated Take, NMFS Daily Method[2] Level A[3]	Level B[4]	Requested Take as % of Pop.[5]	Requested Level A + B Take Authorization[6]
Mysticetes					
Southern right whale	*0*	*0*	0	*0.10*	***12**[7]*
Pygmy right whale	0	0	0	N.A.	**1**[8]
Humpback whale	*1.22*	*14*	85	*0.24*	***99***
Common (dwarf) minke whale	0.61	7	42	0.01	**49**
Antarctic minke whale	0	0	0	<0.01	**2**[8]
Bryde's whale	0.03	0	3	0.03	**3**
Sei whale	*0.02*	*0*	2	*0.10*	***10**[7]*
Fin whale	*2.43*	*28*	168	*1.31*	***196***
Blue whale	*4.78*[9]	*55*	332	*10.2*	***387***
Odontocetes					
Sperm whale	*1.32*	*15*	92	*2.58*	***107***
Dwarf sperm whale	0	0	0	0.02	**2**[8]
Pygmy sperm whale	4.14	47	288	N.A.	**335**
Cuvier's beaked whale	4.02	46	280	1.63	**326**
Shepherd's beaked whale	0	0	0	N.A.	**10**[8]
Southern bottlenose whale	0	0	0	0.01	**4**[8]
Pygmy beaked whale	0	0	0	0.01	**3**[8]
Blainville's beaked whale	0.31	4	21	0.10	**25**
Mesoplodont spp.[10]	0.31	4	21	N.A.	**25**
Chilean dolphin	10.9	125	758	N.A.	**883**
Common bottlenose dolphin	2.72	31	190	0.07	**221**
Striped dolphin	17.7	202	1231	0.15	**1433**
Short-beaked common dolphin	516.9	5903	35,956	2.37	**41,859**
Dusky dolphin	29.9	341	2079	N.A.	**2420**
Peale's dolphin	10.9	125	758	N.A.	**883**
Hourglass dolphin	0	0	0	<0.01	**5**[8]
Southern right whale dolphin	9.79	112	681	N.A.	**793**
Risso's dolphin	10.9	125	758	0.80	**883**
Pygmy killer whale	0	0	0	0.07	**28**[8]
False killer whale	0	0	0	0.03	**11**[8]
Killer whale	0.73	8	51	0.70	**59**
Long-finned pilot whale	0.53	6	37	0.02	**43**
Short-finned pilot whale	0	0	0	<0.01	**18**[7]
Burmeister's porpoise	55.4	632	3853	N.A.	**4485**
Pinnipeds					
Juan Fernandez fur seal	0	0	0	0.01	**3**[8]
South American fur seal	37.9	131	2937	12.5	**3068**
South American sea lion	393.0	1360	30,464	12.5	**31,824**
Southern elephant seal	0	0	0	<0.01	**2**[8]

[1] Except for blue whales, no correction factors were applied to these calculations; see text for density sources; N.A. = not available.
[2] Take using NMFS daily method for calculating ensonified area: estimated density multiplied by the daily ensonified area on 3 selected days, 1 in each of 3 subareas, multiplied by the number of survey days (9) in each subarea times 1.25; daily ensonified areas used to calculate Level B takes = full 160-dB (7197.9 km^2) area minus the 180-dB (1015.0 km^2) or 190-dB (307.6 km^2) areas.
[3] Level A takes if there were no mitigation measures, based on the 180- and 190-dB criteria for cetaceans and pinnipeds, respectively.
[4] Level B takes, based on the 160-dB criterion, excluding exposures to sound levels ≥180 dB (Level A takes).
[5] Requested Level A and B takes (used by NMFS as proxy for number of individuals exposed) expressed as % of population.
[6] Requested take authorization is Level A plus Level B calculated takes, unless otherwise indicated.
[7] Requested take authorization increased to 0.1% for ESA-listed species; increases made to Level B takes only.
[8] Requested take authorization (Level B only) increased to mean group size for non-listed species (see text for sources).
[9] Density of 9.56/km^2 based on Galletti et al. (2012), reduced by 50%; a lower density (2.07/km^2) is expected during winter/spring.
[10] May include Hector's, Gray's, Andrew's, Blainville's, strap-toothed, and/or spade-toothed beaked whales.

(2014); it was estimated to be a fraction of the South American sea lion density using the proportional difference in population sizes for each species (see Table 2). No density estimates are available for the Juan Fernandez fur seal or southern elephant seal, both of which are considered rare. Their density estimates were thus considered to be zero.

There is some uncertainty about the representativeness of the estimated density data and the assumptions used in their calculations. Oceanographic conditions, including occasional El Niño and La Niña events, influence the distribution and numbers of marine mammals present in the ETP, resulting in considerable year-to-year variation in the distribution and abundance of many marine mammal species. Thus, for some species, the densities derived from past surveys may not be representative of the densities that would be encountered during the proposed seismic surveys. However, the approach used here is based on the best available data. The calculated exposures that are based on these densities are best estimates for the proposed survey for any time of the year.

The estimated numbers of individuals potentially exposed are based on the 160-dB re 1 μPa_{rms} criterion for all cetaceans and pinnipeds. It is assumed that marine mammals exposed to airgun sounds that strong could change their behavior sufficiently to be considered "taken by harassment". Tables 3–5 show the density estimates calculated as described above and the estimates of the number of marine mammals that potentially could be exposed to ≥160 dB re 1 μPa_{rms} during the seismic surveys in the northern, central, and southern proposed survey areas off Chile outside of Territorial Waters, respectively, if no animals moved away from the survey vessel. The *Requested Take Authorization* is given in the far right column of Tables 3–5. For all species, including those for which densities were not available or zero, we have included a *Requested Take Authorization* for the mean group size for the non-listed species where that number was higher than the calculated take, and for at least 0.1% of the population for ESA-listed species. The species and sources used include the pygmy right whale (Kemper 2009); Antarctic minke whale and hourglass dolphin (Williams et al. 2006); Shepherd's beaked whale (Mead 2009); southern bottlenose whale (Gowans 2009); dwarf sperm, pygmy killer, false killer, killer, and pilot whales, and *Mesoplodon* sp. for pygmy beaked whale (Wade and Gerrodette 1993); and southern elephant seal (Branch and Butterworth 2001). The mean group size for the South American fur seal (Dassis et al. 2012) was used for the Juan Fernandez fur seal. Although marine otters could be exposed to sounds ≥160 dB in the nearshore environment, no takes are requested, as all otters would occur within Territorial Waters of Chile where the MMPA does not apply.

It should be noted that the following estimates of exposures assume that the proposed surveys would be completed; in fact, the calculated takes ***have been increased by 25%*** (see below). Thus, the following estimates of the numbers of marine mammals potentially exposed to sounds ≥160 dB re 1 μPa_{rms} are precautionary and probably overestimate the actual numbers of marine mammals that could be involved.

Consideration should be given to the hypothesis that delphinids are less responsive to airgun sounds than are mysticetes, as referenced in both the PEIS and "Summary of Potential Airgun Effects" of this document. The 160-dB (rms) criterion currently applied by NMFS, on which the Level B estimates are based, was developed primarily using data from gray and bowhead whales. The estimates of "takes by harassment" of delphinids are thus considered precautionary. As noted previously, in July 2015, NOAA made available for public comment revised draft guidance for assessing the effects of anthropogenic sound on marine mammals (NOAA 2015), although at the time of preparation of this Draft EA, the content of the final guidelines and how they would be implemented are uncertain. Available data suggest that the current use of a 160-dB criterion could be improved upon, as behavioral response might not occur for some percentage of marine mammals exposed to received levels >160 dB, whereas other individuals or groups might respond in a manner considered as "taken" to sound levels <160 dB (NMFS 2013c). It has become evident that the context of an exposure of a marine mammal to sound can affect the animal's initial response to the sound (NMFS 2013c).

Potential Number of Marine Mammals Exposed

The number of marine mammals that could be exposed to airgun sounds with received levels ≥160 and ≥180 or ≥190 dB re 1 μPa_{rms} on one or more occasions have been estimated using a method required by NMFS for calculating the marine area that would be within the 160-dB, 180-dB, and 190-dB radii around the operating seismic source, along with the expected density of animals in the area. NMFS' method was developed to account in some way for the number of exposures as well as the number of individuals exposed. It involves selecting a seismic trackline(s) that could be surveyed on one day; the 160-km line(s) selected had a proportion of depth intervals (>100 m, 100–1000 m, and >1000 m) with their associated radii that was roughly similar to that of the entire survey. The area expected to be ensonified on that day was determined by entering the planned survey lines into a MapInfo GIS, using the GIS to identify the relevant areas by "drawing" the applicable 160-dB, 180-dB, or 190-dB buffer (see Table 1) around each seismic line, and then calculating the total area within the buffers that was outside Territorial Waters. For the southern proposed survey area, it was decided to select daily lines in three subareas because of the geometry of the tracklines and depth contours: the inner north-south line, the outer north-south line, and one east-west line. The ensonified areas were then multiplied by the number of survey days increased by 25%; this is equivalent to adding an additional 25% to the proposed line km for a total of ~12,040 km.

Applying the approach described above, the resulting ensonified areas were ~84,913 km^2, 12,213 km^2, and 80,976 km^2 for the 160-dB isopleth during the northern, central, and southern proposed surveys, respectively. The approach assumes that no cetaceans would move away or toward the trackline in response to increasing sound levels before the levels reach 160 dB as the *Langseth* approaches.

The estimates of the numbers of cetaceans and pinnipeds that could be exposed to seismic sounds with received levels ≥180 dB re 1 μPa_{rms} or 190 dB re 1 μPa_{rms}, respectively, if there were no mitigation measures (power downs or shut downs for observed animals approaching or inside the EZs) are also given in Tables 3–5. It is emphasized that those numbers considerably overestimate actual Level A takes because mitigation measures would strongly reduce if not eliminate any such takes.

Northern Proposed Survey Area

The estimate of the number of cetaceans that could be exposed to seismic sounds with received levels ≥160 dB re 1 μPa_{rms} in the northern proposed survey area is 48,366 (Table 3). That total includes 292 cetaceans listed as ***Endangered*** under the ESA: 119 fin whales, 101 sperm whales, 45 blue whales, and 27 humpback whales, representing 0.79%, 2.44%, 1.20%, and 0.07% of their regional populations, respectively.

In addition, 424 beaked whales could be exposed. Most (95.4%) of the cetaceans potentially exposed would be delphinids; the short-beaked common dolphin, striped dolphin, long-beaked common dolphin, and Risso's dolphin are estimated to be the most common delphinid species in the area, with estimates of 30,253, 5210, 4267, and 2533 exposed to ≥160 dB re 1 μPa_{rms}, respectively (0.54–2.29% of the regional populations). The estimate of the number of pinnipeds that could be exposed to seismic sounds with received levels ≥160 dB re 1 μPa_{rms} is 36,588, most (91.2%) of which would be South American sea lions (13.1% of the regional population).

Central Proposed Survey Area

The estimate of the number of cetaceans that could be exposed to seismic sounds with received levels ≥160 dB re 1 μPa_{rms} in the central proposed survey area is 8258 (Table 4). That total includes 70 cetaceans listed as ***Endangered*** under the ESA: 26 blue whales, 24 fin whales, 15 sperm whales, and 5 humpback whales, representing 0.67%, 0.16%, 0.36%, and 0.01% of their regional populations, respectively.

In addition, 63 beaked whales could be exposed. Most (95.9%) of the cetaceans potentially exposed would be delphinids; the short-beaked common dolphin and the striped dolphin are estimated to be the most common delphinid species in the area, with estimates of 6149 and 570 exposed to ≥160 dB re 1 μPa_{rms}, respectively (0.35% and 0.06% of their regional populations, respectively). The estimate of the number of pinnipeds that could be exposed to seismic sounds with received levels ≥160 dB re 1 μPa_{rms} is 5263, most (91.2%) of which would be South American sea lions (1.9% of the regional population).

Southern Proposed Survey Area

The estimate of the number of cetaceans that could be exposed to seismic sounds with received levels ≥160 dB re 1 μPa_{rms} in the southern proposed survey area is 55,516 (Table 5). That total includes 791 cetaceans listed as ***Endangered*** under the ESA: 387 blue whales, 196 fin whales, 107 sperm whales, 99 humpback whales, and 2 sei whales, representing 10.2%, 1.31%, 2.58%, 0.24%, and 0.02% of their regional populations, respectively.

In addition, 376 beaked whales could be exposed. Most (89.1%) of the cetaceans potentially exposed would be delphinids; the short-beaked common dolphin, Burmeister's porpoise, dusky dolphin, and striped dolphin are estimated to be the most common delphinid species in the area, with estimates of 41,859, 4485, 2420, and 1433 exposed to ≥160 dB re 1 μPa_{rms}, respectively (0.15–2.37% of the regional populations). The estimate of the number of individual pinnipeds that could be exposed to seismic sounds with received levels ≥160 dB re 1 μPa_{rms} is 34,892, most (91.2%) of which would be South American sea lions (12.5% of the regional population).

Conclusions

The proposed seismic project would involve towing a 36-airgun array with a total discharge volume of 6600 in^3 that introduces pulsed sounds into the ocean. Routine vessel operations, other than the proposed seismic operations, are conventionally assumed not to affect marine mammals sufficiently to constitute "taking". In § 3.6.7, § 3.7.7, and § 3.8.7, the PEIS concluded that airgun operations with implementation of the proposed monitoring and mitigation measures could result in a small number of Level B behavioral effects in some mysticete, odontocete, and pinniped species and that Level A effects were highly unlikely. Nonetheless, NSF, L-DEO, OSU, and UT were required by NMFS to calculate and request potential Level A takes for the Proposed Action (following a different methodology than used in the PEIS and most previous analyses for NSF-funded seismic surveys). For two past NSF-funded seismic surveys, NMFS issued small numbers of Level A take for some marine mammal species for the remote possibility of low-level physiological effects; however, NMFS expected neither mortality nor serious injury of marine mammals to result from the surveys (NMFS 2015c, 2016).

Estimates of the numbers of marine mammals that could be exposed to airgun sounds during the proposed program have been presented, together with the requested "take authorization". The estimated numbers of animals potentially exposed to sound levels sufficient to cause Level A and/or B harassment are low percentages of the regional population sizes (Tables 3–5). The estimates are likely overestimates of the actual number of animals that would be exposed to and would react to the seismic sounds. The reasons for that conclusion are outlined above. The relatively short-term exposures are unlikely to result in any long-term negative consequences for the individuals or their populations. Therefore, no significant impacts on cetaceans or pinnipeds would be expected from the proposed activity.

In decades of seismic surveys carried out by the *Langseth* and its predecessor, the R/V *Ewing*, protected species observers (PSOs) and other crew members have seen no seismic sound-related marine mammal injuries or mortality. Also, actual numbers of animals potentially exposed to sound levels sufficient to cause disturbance (i.e., are considered takes) have almost always been much lower than predicted and authorized takes. For example, during an NSF-funded, ~5000-km, 2-D seismic survey conducted by the *Langseth* off the coast of North Carolina in September–October 2014, only 296 cetaceans were observed within the predicted 160-dB zone and potentially taken, representing <2% of the 15,498 takes authorized by NMFS (RPS 2015). During an USGS-funded, ~2700 km, 2-D seismic survey conducted by the *Langseth* along the U.S. east coast in August–September 2014, only 3 unidentified dolphins were observed within the 160-dB zone and potentially taken, representing <0.03% of the 11,367 authorized takes (RPS 2014). Furthermore, as defined, all animals exposed to sound levels >160 dB are Level B 'takes' whether or not a behavioral response occurred. The EZs, which are based on predicted sound levels, are thought to be conservative; thus, not all animals detected within the EZs would be expected to have been exposed to actual sound levels >160 dB.

VIII. Anticipated Impact on Subsistence

The anticipated impact of the activity on the availability of the species or stocks of marine mammals for subsistence uses.

There is no subsistence hunting near the proposed survey areas, so the proposed activity would not have any impact on the availability of the species or stocks for subsistence users.

IX. Anticipated Impact on Habitat

The anticipated impact of the activity upon the habitat of the marine mammal populations, and the likelihood of restoration of the affected habitat.

The proposed seismic surveys would not result in any permanent impact on habitats used by marine mammals or to the food sources they use. The main impact issue associated with the proposed activity would be temporarily elevated noise levels and the associated direct effects on marine mammals, as discussed in § VII, above.

Effects of seismic sound on marine invertebrates (crustaceans and cephalopods), marine fish, and their fisheries are discussed in § 3.2.4 and § 3.3.4 and Appendix D of the PEIS. The PEIS concluded that there could be changes in behavior and other non-lethal, short-term, temporary impacts, and injurious or mortal impacts on a small number of individuals within a few meters of a high-energy acoustic source, but that there would be no significant impacts of NSF-funded marine seismic research on populations.

X. Anticipated Impact of Loss or Modification of Habitat on Marine Mammals

The anticipated impact of the loss or modification of the habitat on the marine mammal populations involved.

The proposed activity is not expected to have any habitat-related effects that could cause significant or long-term consequences for individual marine mammals or their populations, because operations would be limited in duration. However, a small minority of the marine mammals that are present near the proposed activity may be temporarily displaced as much as a few kilometers by the planned activity.

XI. Mitigation Measures

The availability and feasibility (economic and technological) of equipment, methods, and manner of conducting such activity or other means of effecting the least practicable adverse impact upon the affected species or stocks, their habitat, and on their availability for subsistence uses, paying particular attention to rookeries, mating grounds, and areas of similar significance.

Marine mammals and sea turtles are known to occur in the proposed survey areas. To minimize the likelihood that impacts would occur to the species and stocks, airgun operations would be conducted in accordance with the MMPA and the ESA, including obtaining permission for incidental harassment or incidental 'take' of marine mammals and other endangered species. The proposed activity would take place in the EEZ of Chile, including Territorial Waters.

The following subsections provide more detailed information about the mitigation measures that are an integral part of the planned activity. The procedures described here are based on protocols used during previous L-DEO seismic research cruises as approved by NMFS, and on best practices recommended in Richardson et al (1995), Pierson et al. (1998), Weir and Dolman (2007), Nowacek et al. (2013), Wright (2014), and Wright and Cosentino (2015).

Planning Phase

As discussed in § 2.4.1.1 of the PEIS, mitigation of potential impacts from the proposed activity begins during the planning phase of the proposed activity. Several factors were considered during the planning phase of the proposed activity, including

1. *Energy Source*—Part of the considerations for the proposed marine seismic surveys was to evaluate whether the research objectives could be met with a smaller energy source than the full 36-airgun, 6600-in^3 *Langseth* array. It was decided that the scientific objectives for the surveys could not be met using a smaller source as it would not produce enough low-frequency energy with a consistent pulse shape at the interval needed to achieve the necessary propagation distances. Additionally, a large airgun array would assure sufficiently strong signal return from targets, which are as deep as ~15 km.
2. *Survey Timing*—The PIs are working with L-DEO and NSF to identify potential times to carry out the proposed surveys taking into consideration key factors such as environmental conditions (i.e., the seasonal presence of marine mammals, sea turtles, and seabirds), weather conditions, equipment, and optimal timing for other proposed seismic surveys using the *Langseth*. Most marine mammal species are expected to occur in the area year-round, but some migratory baleen whales occur in the area on a seasonal basis. It is likely that fewer baleen whales would occur in the region during austral summer, as they typically occur in lower latitudes at that time. An exception is the blue whale, which has been shown to occur in feeding aggregations in the southern portion of the southern proposed survey area during the austral summer, particularly February–April; this has been taken into account in the take estimates.
3. *Mitigation Zones*—During the planning phase, mitigation zones for the proposed surveys were calculated based on modeling by L-DEO for both the EZ and the safety zone; these zones are given in Table 1. The proposed surveys would acquire data with the 36-airgun array at a tow

depth of 9–12 m. For deep water (>1000 m), we use the deep-water radii obtained from L-DEO model results down to a maximum water depth of 2000 m. The radii for intermediate water depths (100–1000 m) are derived from the deep-water ones by applying a correction factor (multiplication) of 1.5, such that observed levels at very near offsets fall below the corrected mitigation curve. The shallow-water radii are obtained by scaling the empirically derived measurements from the GoM calibration survey to account for the difference in tow depth between the calibration survey (6 m) and the proposed survey (9–12 m). A more detailed description of the modeling process used to develop the mitigation zones can be found in § I.

Table 1 shows the 180- and 190-dB EZs and 160-dB "Safety Zone" (distances at which the rms sound levels are expected to be received) for the mitigation airgun and the 36-airgun array. The 180- and 190-dB re 1 μPa_{rms} distances are the safety criteria as specified by NMFS (2000) for cetaceans and pinnipeds, respectively. Southall et al. (2007) made detailed recommendations for new science-based noise exposure criteria. In July 2015, NOAA published a revised version of its 2013 draft guidance for assessing the effects of anthropogenic sound on marine mammals (NOAA 2015). At the time of preparation of this request, the content of the final guidelines and how they would be implemented are uncertain. As such, this document has been prepared in accordance with the current NOAA acoustic practices, and the procedures are based on best practices noted by Pierson et al. (1998), Weir and Dolman (2007), Nowacek et al. (2013), Wright (2014), and Wright and Cosentino (2015).

The 180-dB distance would also be used as the EZ for sea turtles, as required by NMFS in most other recent seismic projects per the IHAs. Enforcement of mitigation zones via power and shut downs would be implemented during operations, as noted below.

Mitigation During Operations

Mitigation measures that would be adopted during the proposed surveys include (1) power-down procedures, (2) shut-down procedures, and (3) ramp-up procedures.

Power-down Procedures

A power down involves decreasing the number of airguns in use such that the radius of the 180-dB (or 190-dB) zone is decreased to the extent that marine mammals or turtles are no longer in or about to enter the EZ. The acoustic source would also be powered down in the event an ESA-listed seabird were observed diving or foraging within the designated EZ. During a power down, one airgun would be operated. The continued operation of one airgun is intended to alert marine mammals and turtles to the presence of the seismic vessel in the area. In contrast, a shut down occurs when all airgun activity is suspended.

If a marine mammal or turtle is detected outside the EZ but is likely to enter the EZ, the airguns would be powered down before the animal is within the EZ. Likewise, if a mammal or turtle is already within the EZ when first detected, the airguns would be powered down immediately. During a power down of the airgun array, the 40-in^3 airgun would be operated. If a marine mammal or turtle is detected within or near the smaller EZ around that single airgun (Table 1), it would be shut down (see next sub-section).

Following a power down, airgun activity would not resume until the marine mammal or turtle has cleared the safety zone. The animal would be considered to have cleared the safety zone if

- it is visually observed to have left the EZ, or
- it has not been seen within the zone for 15 min in the case of small odontocetes, or

- it has not been seen within the zone for 30 min in the case of mysticetes and large odontocetes, including sperm, pygmy sperm, dwarf sperm, and beaked whales, or
- the vessel has moved outside the EZ for turtles, e.g., if a turtle is sighted close to the vessel and the ship speed is 8.3 km/h, it would take the vessel ~15 min to leave the turtle behind.

During airgun operations following a shut down whose duration has exceeded the time limits specified above, the airgun array would be ramped up gradually. Ramp-up procedures are described below. During past *Langseth* marine geophysical surveys, following an extended power-down period, the seismic source followed ramp-up procedures to return to the full seismic source level. Under a power-down scenario, however, a single mitigation airgun still would be operating to alert and warn animals of the on-going activity. Furthermore, under these circumstances, ramp-up procedures may unnecessarily extend the length of the survey time needed to collect seismic data. L-DEO and NSF have concluded in consultation with NMFS that ramp up is not necessary after an extended power down. Therefore, this practice is not included here as part of the monitoring and mitigation plan.

Shut-down Procedures

The operating airgun(s) would be shut down if a marine mammal or turtle is seen within or approaching the EZ for the single airgun. The operating airgun(s) would also be shut down in the event an ESA-listed seabird were observed diving or foraging within the designated EZ.

Shut downs would be implemented (1) if an animal enters the EZ of the single airgun after a power down has been initiated, or (2) if an animal is initially seen within the EZ of the single airgun when more than one airgun (typically the full array) is operating. Airgun activity would not resume until the marine mammal or turtle has cleared the safety zone, or until the PSO is confident that the animal has left the vicinity of the vessel. Criteria for judging that the animal has cleared the safety zone would be as described in the preceding subsection.

Ramp-up Procedures

A ramp-up procedure would be followed when the airgun array begins operating after a specified period without airgun operations. It is proposed that, for the present survey, this period would be ~8 min. Similar periods (~8–10 min) were used during previous L-DEO surveys. Ramp up would not occur if a marine mammal or sea turtle has not cleared the safety zone as described earlier.

Ramp up would begin with the smallest airgun in the array (40 in^3). Airguns would be added in a sequence such that the source level of the array would increase in steps not exceeding 6 dB per 5-min period. During ramp up, the PSOs would monitor the EZ, and if marine mammals or turtles are sighted, a power down or shut down would be implemented as though the full array were operational.

If the complete EZ has not been visible for at least 30 min prior to the start of operations in either daylight or nighttime, ramp up would not commence unless at least one airgun (40 in^3 or similar) has been operating during the interruption of seismic survey operations. Given these provisions, it is likely that the airgun array would not be ramped up from a complete shut down at night or in thick fog, because the outer part of the safety zone for that array would not be visible during those conditions. If one airgun has operated during a power-down period, ramp up to full power would be permissible at night or in poor visibility, on the assumption that marine mammals and turtles would be alerted to the approaching seismic vessel by the sounds from the single airgun and could move away. Ramp up of the airguns would not be initiated if a sea turtle or marine mammal is sighted within or near the applicable EZs during the day or night.

As noted above under "Power-down Procedures", during past R/V *Langseth* marine geophysical surveys, following an extended power-down period, the seismic source followed ramp-up procedures to return to the full seismic source level. Currently, under a power-down scenario, however, a single mitigation airgun still would be operating to alert and warn animals of the on-going activity and therefore ramp-up is viewed unnecessary.

XII. PLAN OF COOPERATION

Where the proposed activity would take place in or near a traditional Arctic subsistence hunting area and/or may affect the availability of a species or stock of marine mammal for Arctic subsistence uses, the applicant must submit either a plan of cooperation or information that identifies what measures have been taken and/or will be taken to minimize any adverse effects on the availability of marine mammals for subsistence uses. A plan must include the following:

(i) A statement that the applicant has notified and provided the affected subsistence community with a draft plan of cooperation;

(ii) A schedule for meeting with the affected subsistence communities to discuss proposed activities and to resolve potential conflicts regarding any aspects of either the operation or the plan of cooperation;

(iii) A description of what measures the applicant has taken and/or will take to ensure that proposed activities will not interfere with subsistence whaling or sealing; and

(iv) What plans the applicant has to continue to meet with the affected communities, both prior to and while conducting activity, to resolve conflicts and to notify the communities of any changes in the operation.

Not applicable. The proposed activity would take place in the southeast Pacific Ocean, and no activities would take place in or near a traditional Arctic subsistence hunting area.

XIII. MONITORING AND REPORTING PLAN

The suggested means of accomplishing the necessary monitoring and reporting that will result in increased knowledge of the species, the level of taking or impacts on populations of marine mammals that are expected to be present while conducting activities and suggested means of minimizing burdens by coordinating such reporting requirements with other schemes already applicable to persons conducting such activity. Monitoring plans should include a description of the survey techniques that would be used to determine the movement and activity of marine mammals near the activity site(s) including migration and other habitat uses, such as feeding...

L-DEO proposes to sponsor marine mammal monitoring during the present project, in order to implement the proposed mitigation measures that require real-time monitoring and to satisfy the expected monitoring requirements of the IHA. L-DEO's proposed Monitoring Plan is described below. L-DEO understands that this Monitoring Plan would be subject to review by NMFS and that refinements may be required.

The monitoring work described here has been planned as a self-contained project independent of any other related monitoring projects that may be occurring simultaneously in the same regions. L-DEO is prepared to discuss coordination of its monitoring program with any related work that might be done by other groups insofar as this is practical and desirable.

Vessel-based Visual Monitoring

Observations by PSOs would take place during daytime airgun operations and nighttime start ups of the airguns. Airgun operations would be suspended when marine mammals, turtles, or diving ESA-listed seabirds are observed within, or about to enter, designated EZs [see § XI above] where there is concern about potential effects on hearing or other physical effects. PSOs would also watch for marine mammals and sea turtles near the seismic vessel for at least 30 min prior to the planned start of airgun operations. Observations would also be made during daytime periods when the *Langseth* is underway without seismic operations, such as during transits. PSOs would also watch for any potential impacts of the acoustic sources on fish.

During seismic operations, four visual PSOs (PSVOs) would be based aboard the *Langseth*. All PSOs would be appointed by L-DEO with NMFS concurrence. During the majority of seismic operations, two PSVOs would monitor for marine mammals and sea turtles around the seismic vessel. Use of two simultaneous observers would increase the effectiveness of detecting animals around the source vessel. However, during meal times, only one PSVO may be on duty. PSVO(s) would be on duty in shifts of duration no longer than 4 h. Other crew would also be instructed to assist in detecting marine mammals and turtles and implementing mitigation requirements (if practical). Before the start of the seismic survey, the crew would be given additional instruction regarding how to do so.

The *Langseth* is a suitable platform for marine mammal and turtle observations. When stationed on the observation platform, the eye level would be ~21.5 m above sea level, and the observer would have a good view around the entire vessel. During daytime, the PSVO(s) would scan the area around the vessel systematically with reticle binoculars (e.g., 7×50 Fujinon), Big-eye binoculars (25×150), and with the naked eye. During darkness, night vision devices (NVDs) would be available (ITT F500 Series Generation 3 binocular-image intensifier or equivalent), when required. Laser rangefinding binoculars (Leica LRF 1200 laser rangefinder or equivalent) would be available to assist with distance estimation. Those are useful in training observers to estimate distances visually, but are generally not useful in measuring distances to animals directly; that is done primarily with the reticles in the binoculars.

Passive Acoustic Monitoring

Passive acoustic monitoring (PAM) would take place to complement the visual monitoring program. Visual monitoring typically is not effective during periods of poor visibility or at night, and even with good visibility, is unable to detect marine mammals when they are below the surface or beyond visual range. Acoustical monitoring can be used in addition to visual observations to improve detection, identification, and localization of cetaceans. The acoustic monitoring would serve to alert PSVOs (if on duty) when vocalizing cetaceans are detected. It is only useful when marine mammals call, but it can be effective either by day or by night, and does not depend on good visibility. It would be monitored in real time so that the visual observers can be advised when cetaceans are detected.

The PAM system consists of hardware (i.e., hydrophones) and software. The “wet end” of the system consists of a towed hydrophone array that is connected to the vessel by a tow cable. The tow cable is 250 m long, and the hydrophones are fitted in the last 10 m of cable. A depth gauge is attached to the free end of the cable, and the cable is typically towed at depths <20 m. The array would be deployed from a winch located on the back deck. A deck cable would connect the tow cable to the electronics unit in the main computer lab where the acoustic station, signal conditioning, and processing system would be located. The acoustic signals received by the hydrophones are amplified, digitized, and then processed by the Pamguard software. The system can detect marine mammal vocalizations at frequencies up to 250 kHz.

One acoustic PSO or PSAO, in addition to the four PSVOs, would be on board. The towed hydrophones would ideally be monitored 24 h per day while at the seismic survey areas during airgun operations, and during most periods when the *Langseth* is underway while the airguns are not operating. However, PAM may not be possible if damage occurs to the array or back-up systems during operations. One PSAO would monitor the acoustic detection system at any one time, by listening to the signals from two channels via headphones and/or speakers and watching the real-time spectrographic display for frequency ranges produced by cetaceans. The PSAO monitoring the acoustical data would be on shift for 1–6 h at a time. All observers are expected to rotate through the PAM position, although the most experienced with acoustics would be on PAM duty more frequently.

When a vocalization is detected while visual observations are in progress, the PSAO would contact the PSVO immediately, to alert him/her to the presence of cetaceans (if they have not already been seen), and to allow a power or shut down to be initiated, if required. The information regarding the call would be entered into a database. The data to be entered include an acoustic encounter identification number, whether it was linked with a visual sighting, date, time when first and last heard and whenever any additional information was recorded, position and water depth when first detected, bearing if determinable, species or species group (e.g., unidentified dolphin, sperm whale), types and nature of sounds heard (e.g., clicks, continuous, sporadic, whistles, creaks, burst pulses, strength of signal, etc.), and any other notable information. The acoustic detection could also be recorded for further analysis.

PSO Data and Documentation

PSOs would record data to estimate the numbers of marine mammals, turtles, and diving ESA-listed seabirds exposed to various received sound levels and to document apparent disturbance reactions or lack thereof. They would also record any observations of fish potentially affected by the sound sources. Data would be used to estimate numbers of animals potentially 'taken' by harassment (as defined in the MMPA). They would also provide information needed to order a power or shut down of the airguns when a marine mammal, sea turtle, or diving ESA-listed seabird is within or near the EZ.

When a sighting is made, the following information about the sighting would be recorded:

1. Species, group size, age/size/sex categories (if determinable), behavior when first sighted and after initial sighting, heading (if consistent), bearing and distance from seismic vessel, sighting cue, apparent reaction to the airguns or vessel (e.g., none, avoidance, approach, paralleling, etc.), and behavioral pace.
2. Time, location, heading, speed, activity of the vessel, sea state, visibility, and sun glare.

The data listed under (2) would also be recorded at the start and end of each observation watch, and during a watch whenever there is a change in one or more of the variables.

All observations and power or shut downs would be recorded in a standardized format. Data would be entered into an electronic database. The accuracy of the data entry would be verified by computerized data validity checks as the data are entered and by subsequent manual checking of the database. These procedures would allow initial summaries of data to be prepared during and shortly after the field program, and would facilitate transfer of the data to statistical, graphical, and other programs for further processing and archiving.

Results from the vessel-based observations would provide

1. the basis for real-time mitigation (airgun power down or shut down);
2. information needed to estimate the number of marine mammals potentially taken by harassment, which must be reported to NMFS;
3. data on the occurrence, distribution, and activities of marine mammals, turtles, and diving ESA-listed seabirds in the area where the seismic study is conducted;
4. information to compare the distance and distribution of marine mammals, turtles, and diving ESA-listed seabirds relative to the source vessel at times with and without seismic activity;

5. data on the behavior and movement patterns of marine mammals and turtles seen at times with and without seismic activity; and
6. any observations of fish potentially affected by the sound sources.

A report would be submitted to NMFS and NSF within 90 days after the end of the cruise. The report would describe the operations that were conducted and sightings of marine mammals, turtles, and diving ESA-listed seabirds near the operations. The report would provide full documentation of methods, results, and interpretation pertaining to all monitoring. The 90-day report would summarize the dates and locations of seismic operations, all marine mammal, turtle, and diving ESA-listed seabird sightings (dates, times, locations, activities, associated seismic survey activities), and any observations of fish potentially affected by the sound sources. The report would also include estimates of the number and nature of exposures that could result in "takes" of marine mammals by harassment or in other ways.

XIV. Coordinating Research to Reduce and Evaluate Incidental Take

Suggested means of learning of, encouraging, and coordinating research opportunities, plans, and activities relating to reducing such incidental taking and evaluating its effects.

L-DEO and NSF would coordinate with applicable U.S. agencies (e.g., NMFS) and would comply with their requirements.

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